

CONSTRUCTION TECHNOLOGY



RISM QS EDUCATION SUBCOMMITTEE

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Tel : 603-7954 8358
Fax : 603-7955 0253
Email : secretariat@rism.org.my

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PREFACE

The *Construction Technology* acts as a reference providing the basic tenets of construction under the Malaysian scene. It includes earthwork, sub-structure, and superstructure (floors, frame, stairs, roof, brickwall, doors and windows, finishes as well as plants and machineries). It is written with the conviction that brief explanations with ample illustrations and photographs to depict the real-life construction situations assist in linking the knowledge and practice apart from ease of understanding and comprehension.

The core concept of this reference revolves around providing supplementary lecture support material for construction students and lecturers. This reference underlines the rudimentary knowledge a student should acquire especially in their first year of any construction related qualification. Besides that, it also equips construction professionals or technologist with the necessary basic knowledge in relation to construction technology and activities, in enabling them to comprehend and take on discussions with related specialist. In making this reference well within reach to all readers, we have determined that it should be in the form of e-book. This is in line with the current digitalised construction industry and in support of sustainability.

Ts. Sr Khoo Sui Lai, CQS, FRISM
Editor
October 2021

ACKNOWLEDGEMENTS FROM RISM QS DIVISION EDUCATION SUBCOMMITTEE CHAIR

The Chair would like to express his thanks to all the contributors who had contributed to the chapters of this textbook. This is truly a collaborative effort across universities, university colleges and polytechnic together with the RISM QS Division Education Subcommittee. To the co-editors: Dr. Felicia Yong Yan Yan, Dr. Lew Yoke Lian and Ts. Sr Dr. Nadzirah Hj. Zainordin, who helped with reviewing and proofreading the book.

The professional support from RISM QS Division Chair, Sr Nazir Muhamad Noor towards this book is deeply appreciated and acknowledged.

**Ts. Sr Khoo Sui Lai, *CQS, FRISM*
RISM QS Division Education Subcommittee Chair Session 2021/2022
October 2021**

ACKNOWLEDGEMENTS FROM RISM QS DIVISION CHAIR

Today, new technologies in construction are being developed at a breakneck pace. What seemed like future technology from 10, 20 years ago like connected equipment and tools, telematics, mobile apps, autonomous heavy equipment, drones, robots, augmented and virtual reality, and 3D printed buildings are here and being deployed and used on jobsites across the world.

However, I believe in shaping the fundamental understanding toward construction technology process always a crucial process. As this textbook core concept as serve to be use as supplementary lecturer support material for lecturer and student in Built Environment, the fundamental knowledge can be further develop before speaking about an adopting in line with the technology.

Every construction site is different, presenting its own unique set of challenges and risks. This makes it difficult to streamline processes and increase productivity the way industries like manufacturing and retail have been able to do. Thus, this textbook may further equip not only student which they are also future construction professional with the essential knowledge relating to construction technology and activities involve particularly in Malaysia perspective.

With the content provide, I believe this can be beneficial to all from lecturer, student and include construction professional.

**Sr Nazir Bin Muhamad Nor, PQS, MRISM
RISM QS Division Chair Session 2021/2022
October 2021**

EDITORIAL COMMITTEE

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TOPIC 1

EARTHWORK

INTRODUCTION

Earthwork is the essential process in construction projects which is carried out at the earlier stage of construction. Earthwork involves the process of preparing the building platform level as required in the construction drawing and excavation works. The completion of earthwork within the stipulated time is often the key to completing the entire project without delay. In other words, earthwork is an essential work component in a construction project. Any negligence in carrying out the earthwork will most likely lead to loss of time, cost, and loss of life. Hence, the use of plants and machinery is encouraged to reduce costs and speed up the work.

Earthwork is divided into two main activities, which are:

- i. Site clearance - comprises all necessary site clearance and preparation activities such as removing trees, hedges, and clearing undergrowth.
- ii. Excavation works - consists of various types of excavation, earthworks support, and disposal of groundwater.

SITE CLEARANCE

Site clearance is the removal and disposal of unwanted material such as vegetation, dead stumps, surface boulder embedded in the ground, etc. These materials should not be left and buried at the site, as they will decay gradually and cause a decrease in ground-level settlement leading to building failure. The site clearance process is initiated after site

possession and obtaining the necessary approvals from the Local Authority for cutting of trees.

REMOVING TREES, HEDGES AND UNDERGROWTH

Removing trees, hedges and clearing undergrowth such as shrubs and bushes is the first step that needs to be done at a construction site. This step is carried out to ensure that the construction site area is free from vegetation, allowing site levelling work to be done.

There are three common methods used to carry out the vegetation clearing (Figure 1.1) depending on the size of the area to be cleared, the site location, types and density of vegetation at the construction site, the availability of equipment and personnel, and the time available for completion.

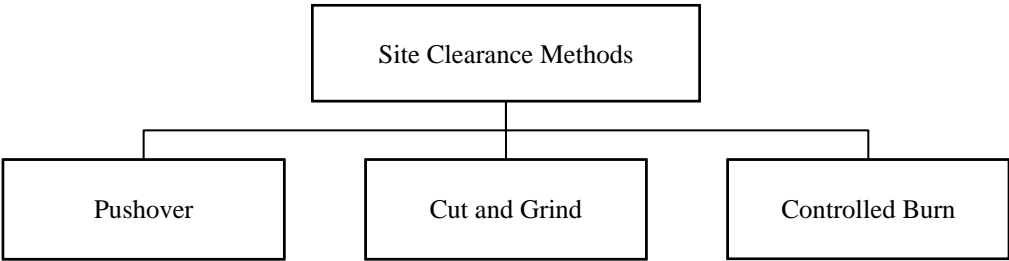


Figure 1.1 Site clearance methods

Pushover Method – This method involves the use of large construction machineries such as backhoe and bulldozer to push the trees over and haul off the soil with the roots intact before transferring them to a central location off-site. This method is effective for large growths such as trees, bushes, and vegetation. However, this method may leave large holes in the ground where the trees once stood, besides having the hedges and undergrowth removed separately.



Figure 1.2 Pushover method



Figure 1.3 Trees moved to a central location in the pushover method

Cut and Grind Method - This method begins with clearing the hedges and undergrowth using suitable machinery. Then, tools such as chainsaw are used to cut down the trees. The tree trunks are often moved to processing locations. Next, the tree stumps that are still left on the ground are pulled out using a large construction machine such as a backhoe.



Figure 1.4 Cutting down trees in cut and grind method



Figure 1.5 Stumps were pulled out further from the ground



Figure 1.6 Tree trunks were moved to a processing location

Controlled Burn – This method involves starting a controlled fire and maintaining the fire until all trees, hedges, and undergrowth are burned to the ground. Next, the land is cleared using machinery such as a bulldozer after the fire is extinguished. Controlled burning can be a cost-effective method, but it also comes with the risk of fire spreading uncontrollably. Besides that, this method also depends on the local authority's laws, rules and regulations as well as conditions.



Figure 1.7 Site clearance using controlled burn method

EXCAVATION WORKS

Excavation work is defined as the removal of soil, rocks, or other materials in connection with construction; using tools, machinery, or explosives to form open surfaces, holes or cavities in the ground (Department of Occupational Safety and Health Malaysia (DOSH), 2017).

For small-scale excavation or in confined spaces, excavation may be carried out using tools such as hoe and shovels. While for large-scale excavation works, plants such as bulldozers and backhoe are required.

TYPES OF EXCAVATION

Excavation works can be classified into two common categories: (1) Based on the types of materials being excavated, and (2) Based on the purpose of the excavation. The common types of excavation are summarised in Figure 1.8.

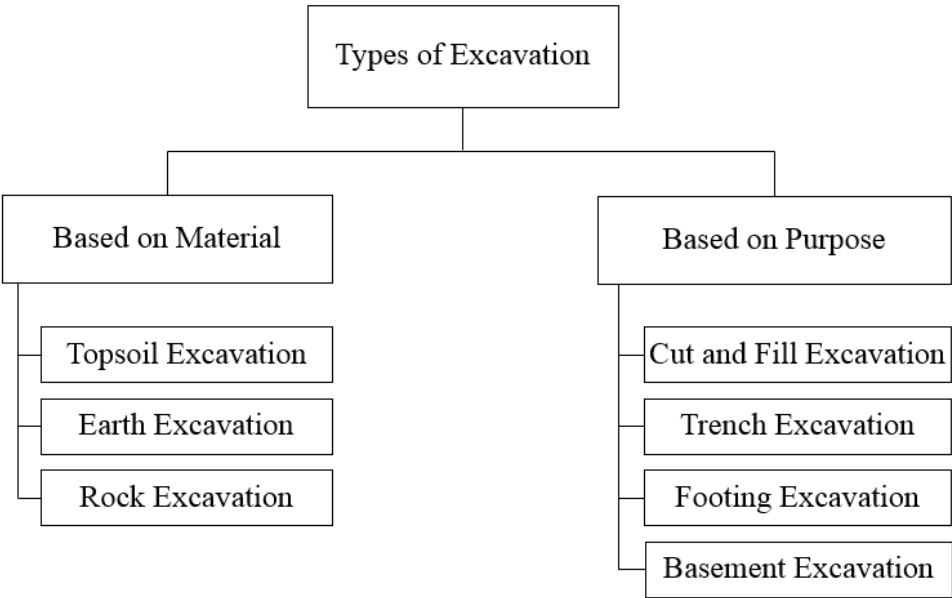


Figure 1.8 Common types of excavation

TYPES OF EXCAVATION BASED ON MATERIAL

Topsoil Excavation

Topsoil excavation is one of the site preparation activities involving the removal of exposed layers of the earth's surface that may contain decaying materials, which could make the soil compressible and unsuitable for bearing the structural loads. Figure 1.9 shows the layer of soil.

The depth for topsoil excavation is usually in the range of 150mm to 300mm, but it may vary from site to site. The excavated topsoil shall be disposed to the specified location as approved by the Superintending Officer or the client.

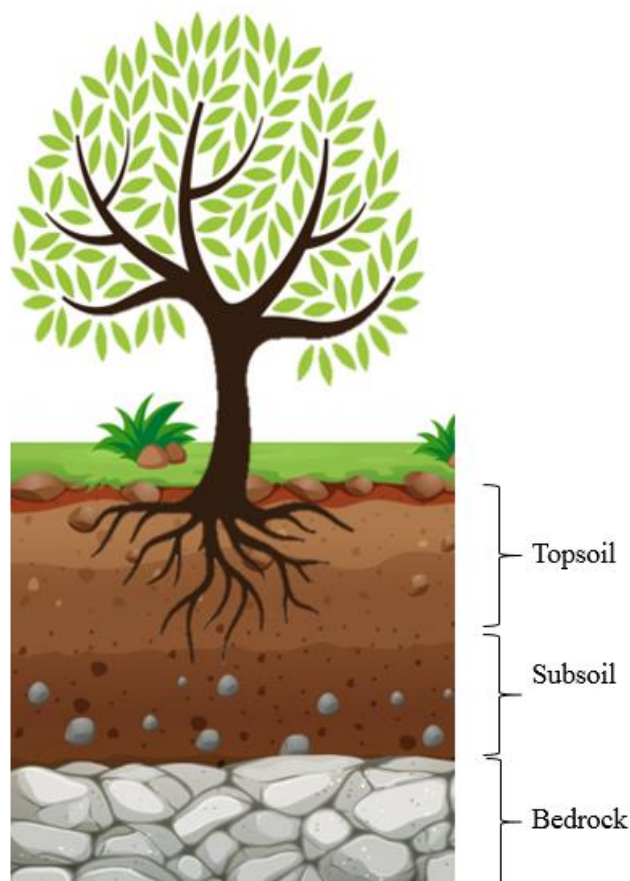


Figure 1.9 Soil layer diagram*



Figure 1.10 Topsoil excavation

Earth Excavation

Earth excavation is the process of removing the soil beneath the topsoil layer. Usually, the excavation works are carried using a backhoe or other types of earthmoving plants and equipment. Usually, the purposes of earth excavation are to construct the building's foundations, basement, and drainage. The excavated materials or referred to as 'spoil' can be used as the filling material to fill the voids to trenches and foundation after the structure is constructed.

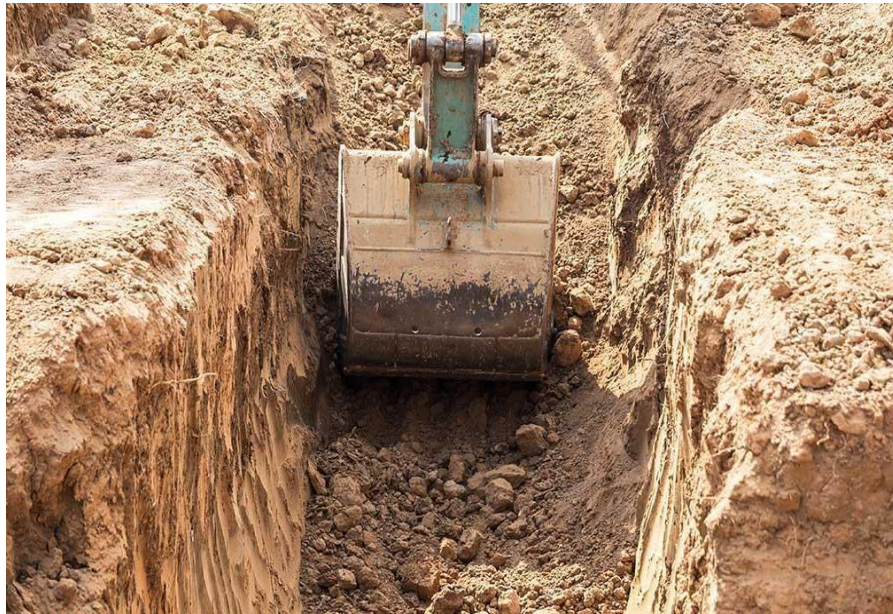


Figure 1.11 Earth excavation

Rock Excavation

Rock excavation is the process to remove all hard or compacted materials formations that cannot be done using typical excavation plants in clearing the surface.

Rock can be found in solid beds; or as isolated boulders of at least one cubic yard or 0.77 cubic meters in volume or more. However, in Malaysia, boulders or detached pieces shall be regarded as rock if they individually exceed 0.50 cubic meters (Public Works Department, 2014).

This type of excavation is highly challenging, as it cannot be done without the use of special equipment and techniques, like drilling or blasting to remove the rock.

In a construction project, forecasting the possibility of rock excavation is often necessary. A thorough soil investigation is required to obtain the needed data. Investigation is carried out in obtaining samples by digging test pits, soil boring, or coring the rock itself. The

engineer can then plan and suggest a suitable technique with the excavation equipment based on the investigation.



Figure 1.12 Rock drilling



Figure 1.13 Rock blasting

TYPES OF EXCAVATION BASED ON PURPOSE

Cut and Fill Excavation

Cut and fill is where the earth is being moved from one place to another to level the ground. This is required for a sloped or uneven site topography condition.

A 'cut' is made when the existing ground level exceeds the required elevation and requiring its removal, while 'fill' is carried out when the ground level is lower than the required elevation.

Filling is done using the excavated materials from the cutting process and/or imported material. One of the critical aspects to consider in cut and fill excavation is soil conservation. The need to export soil from another location resulting from having more fill than cut requires careful planning and thought. Yet, having more cut than fill, on the other hand, results in the need to find places to dispose of the excess soil.

Cut and fill excavation is usually accomplished using bulldozers, excavators, and compactors.

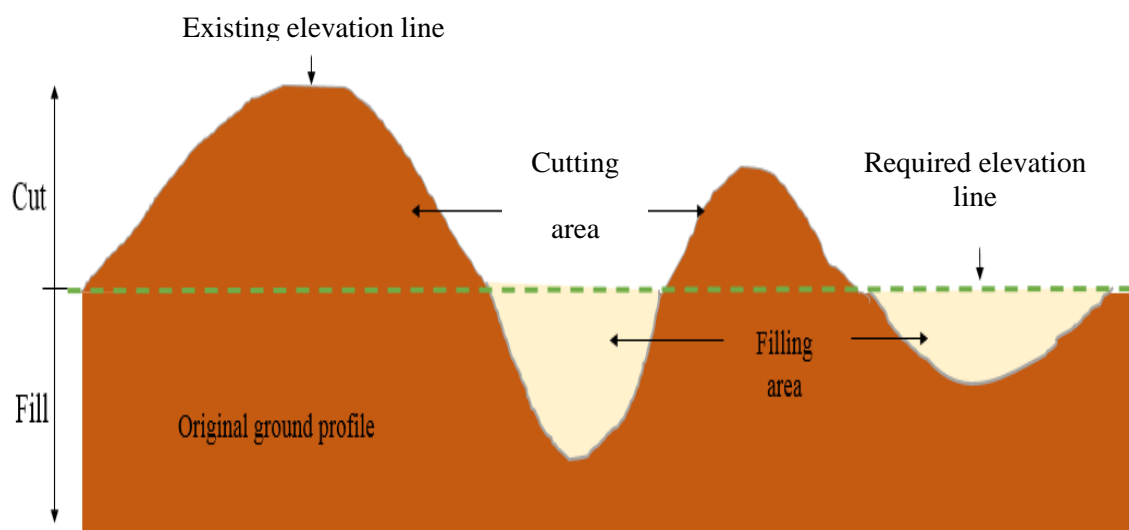


Figure 1.14 Cross-section of a typical cut and fill excavation*



Figure 1.15 Cut and fill excavation at a construction site

Trench Excavation

Soil removal forms a narrow opening in the ground using excavators such as a backhoe is known as trench excavation.

Typically, the length of the excavated area exceeds the depth of excavation for this type of excavation. In Malaysia, excavation exceeding 1.50 meters is considered high-risk excavation. Hence, appropriate shoring must be put in place as safety precautions (Department of Occupational Safety and Health Malaysia (DOSH), 2017).

Trench excavation is typically used to form strip foundations in burying underground services, installing pipelines and sewer systems, and constructing surface drainage.

Trench excavation requires several safety measures to ensure the trench stability and the safety of the workers, including the location to deposit the excavated material safely, suitable excavation methods according to the soil type, and shoring needed.

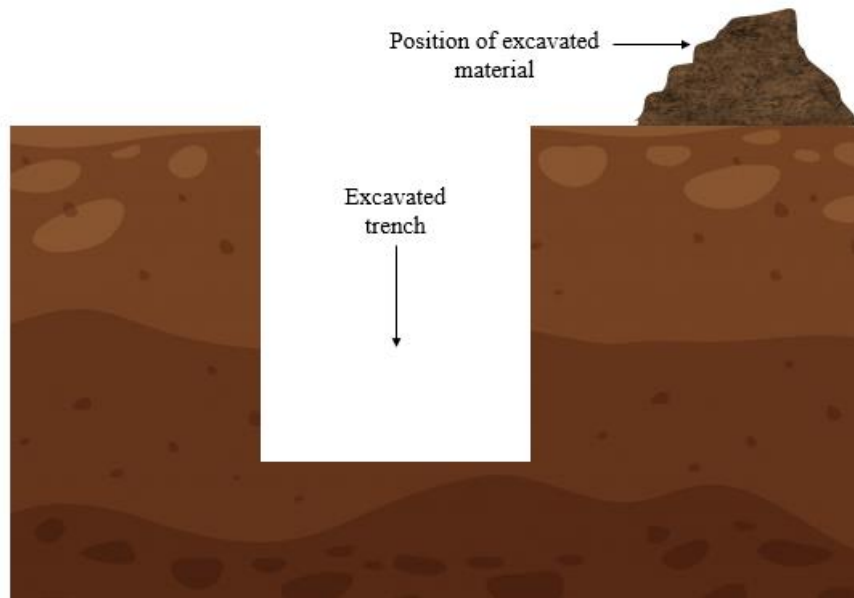


Figure 1.16 Cross-section of a typical trench excavation*



Figure 1.17 Trench excavation at a construction site

Footing Excavation

The footing excavation starts after the construction site has levelled. Foot foundation structures are used to support buildings by spreading the load to the ground.

Foundations are classified into two categories: shallow foundations and deep foundations. Shallow foundations have depths less than 3 meters below the finished ground level, whereas deep foundations have depths over 3 meters (Public Works Department, 2014).

Shallow excavations can be performed without shoring, but not for deep foundations because of safety.

Footing excavation must be precisely done according to the required depths and dimensions, with sides trimmed and bottom levelled, as subsequently, concrete for footings is likely to be poured and left to set.



Figure 1.18 Footing excavation

Basement Excavation

Basement is the lower part of a building that is partially or wholly below ground level. Basement is commonly available in tall buildings as carparks. It can also serve as underground shopping areas or services storage.

Basement excavation is a risky process since it involves large and deep excavation areas. The complexity of basement excavation relies on the depth, level of the groundwater table, and location of the site. Hence, detailed soil investigation is critical in planning the excavation methods for the basement and forecasting the difficulties that may arise.

Basement excavation can be carried out using a backhoe or excavator and any other special equipment or machinery, depending on the complexity of the excavation.

Basement excavation falls under deep excavation category that requires appropriate shoring or strutting, and the groundwater must be adequately controlled to avoid any unwanted accidents. Adequate measures are vital in ensuring that all parts of the excavation area are free from overload caused by adjacent vehicles, plants, or excavated soil to prevent landslides in the excavated area.

The most common risks in basement excavation are:

- Poor ground conditions; ground heaving or settlement
- Obstructions from surrounding areas such as existing cables or pipelines
- Loads from adjacent buildings and roads
- Foundations of nearby properties that may be affected

There are three common methods in basement excavation:

Open cut method – This is the simplest method where the sides of the excavation are sloped to provide stability with suitable slope protection techniques. Upon excavating to the required depth, the basement is constructed from bottom up. Next, the remaining excavated

areas between the basement and side slope are backfilled with soil obtained from the excavation and/or imported soil after basement construction is completed.

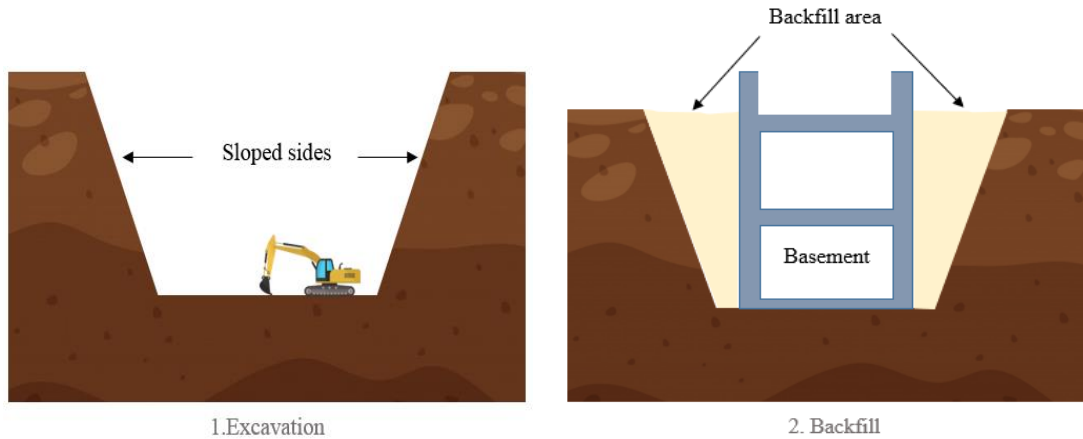


Figure 1.19 Open cut basement excavation method*

Cut and cover method – This method is usually applied in congested sites where ground movements to the adjacent surrounding must be kept to a minimum. This method uses retaining walls and strutting to support the excavation sides as the excavation proceeds downward. Then, the basement construction progresses upwards on both sides in sequence with the removal of the temporary struts. After the basement construction is completed, the remaining spaces between the basement and side slope will be backfilled.

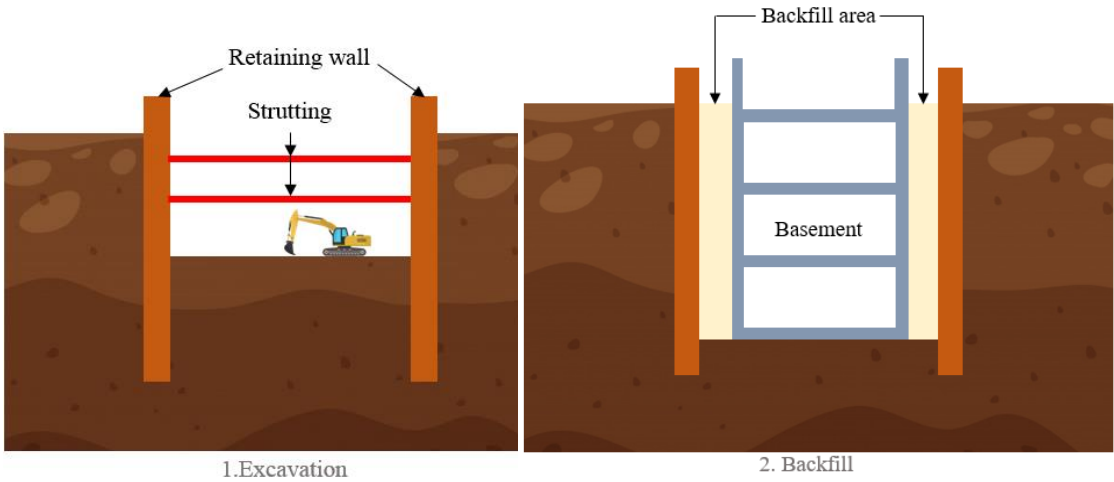


Figure 1.20 Cut and cover basement excavation method*

Top-down method – As the name implies, this excavation method is done phase by phase, from top to bottom in sequence. This method is employed when the usage of deep excavation is required, soil movement must be minimized, and completion time is the top priority. The construction begins with retaining wall installation and basement columns before excavation works for this top-down method. Then, the higher-level slab is constructed as the horizontal frame to support the walls as the excavation progressed downward, followed by the construction of the lower basement slabs.

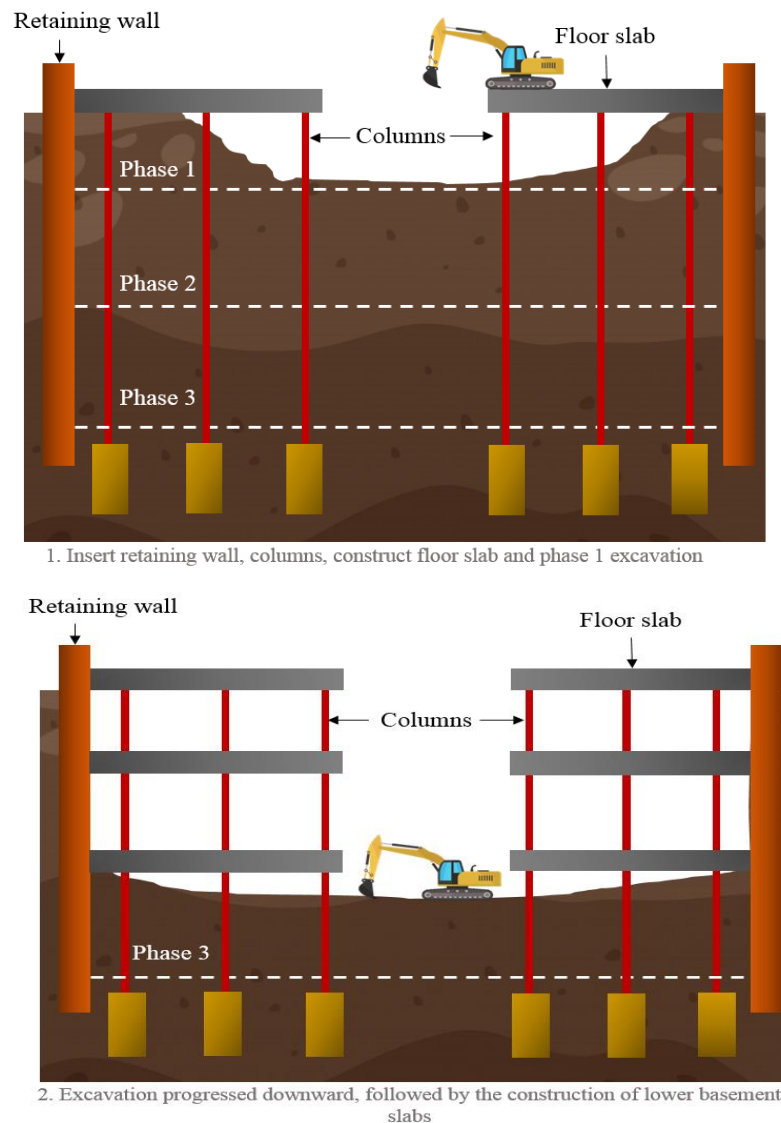


Figure 1.21 Top-down basement excavation method*



Figure 1.22 Basement excavation at a construction site

EXCAVATION SUPPORT

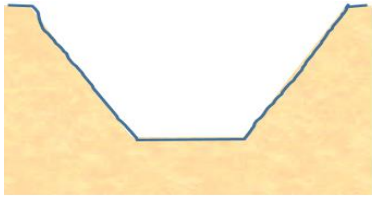
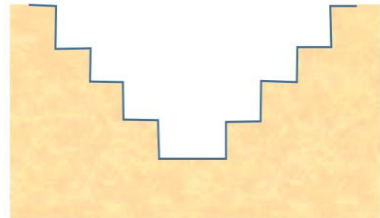
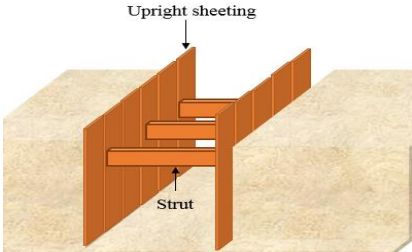
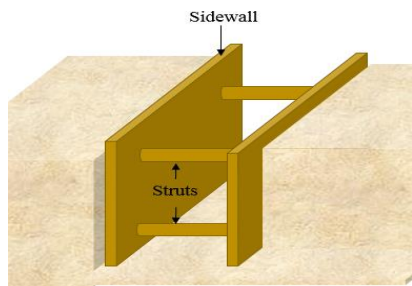
Excavation support is needed to ensure the excavation areas are stable and free from any hazards such as landslides. The types of excavations depend on several factors:

Types and stability of subsoil:

- Depth of the excavation
- The groundwater tables
- Duration of the excavation will be open
- Weather

In Malaysia, excavation depth over 1.50 meters deep requires support. Table 1.1 shows the types of excavation support according to the Department of Occupational Safety and Health Malaysia (DOSH) (2017).

Table 1.1 Types of excavation support*

| Excavation Support | Description | Illustration |
|--------------------|---|--|
| Sloping | This method is suitable for sites with sufficient space around the excavation in order to construct the required slope ratio. The slope angles vary depending on the soil type and soil moisture level. |  |
| Benching | This method aims to increase the stability of the vertical wall of the excavation by forming a series of stairs. The stairs should be wide enough to stabilise the slope. The vertical distance of the stairs should not exceed 1.2 meters and should not be less than 1.2 meters wide. |  |
| Shoring | Shoring is constructed with pieces of wood or sheet piles installed at the sides of the excavation vertically and supported by wooden or steel struts horizontally. This method is common for trench excavation with unstable soil conditions. |  |
| Shielding | Shielding uses timber or steel plates as the protective system which is fixed at both sides of the excavation wall. The primary purpose of shielding is to protect the workers rather than supporting the excavation. |  |

GROUNDWATER CONTROL

Groundwater refers to water found underground within cracks and spaces in soil, sand, and rock. Groundwater is stored in or moves slowly through the geologic formations of soil

(Figure 1.23). A high groundwater table can complicate the excavation works and endanger workers.

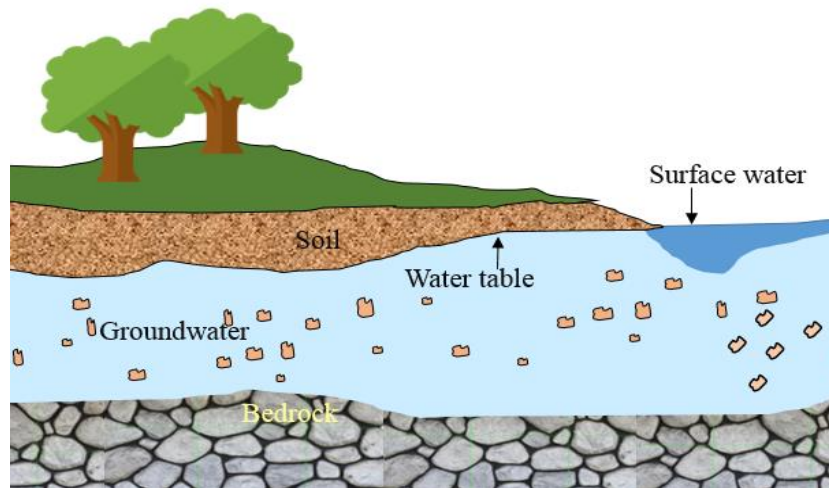


Figure 1.23 Water table aquifer*

Groundwater control or dewatering in construction is the process of dealing with groundwater temporarily for the execution of excavation works in dry and stable conditions. The presence of undesired groundwater in a construction site can lead to safety risks since the water could soften the soil causing landslides at the excavation area. Also, groundwater issues might cause project cost and time overrun. Figure 1.24 and Figure 1.25 illustrate the effects of groundwater issues on excavation work at construction sites.



Figure 1.24 Groundwater problem in basement excavation



Figure 1.25 Groundwater problem in footing excavation

Therefore, appropriate control and dewatering techniques are critical to limit, manage and remove the groundwater. There are three common methods used in controlling and dewatering the groundwater: open pumping, pre-drainage, and exclusion methods.

Open pumping - In this method, the groundwater is permitted to flow into the excavation area. The groundwater is then collected in ditches or sumps before being pumped out.

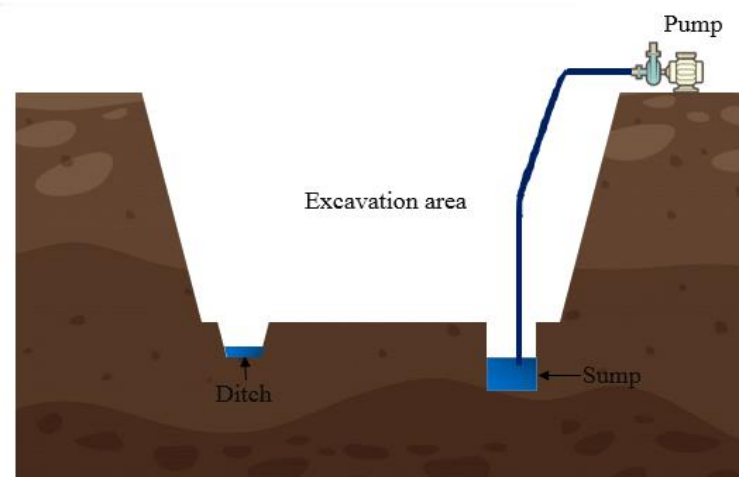


Figure 1.26 Open pumping method*

Pre-drainage – This method is carried out by lowering the groundwater table using pump wells, well points, ejectors and drains before commencing the excavation works.

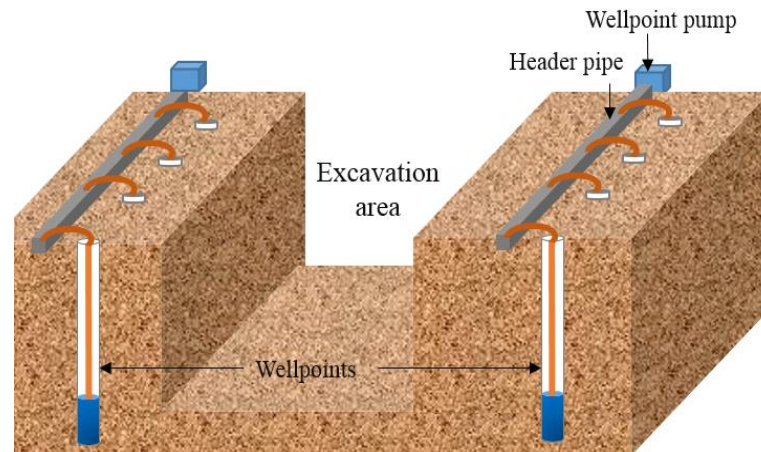


Figure 1.27 Pre-drainage method using well points*

Exclusion – In the exclusion method, the groundwater entry is cut off by the cut-off walls constructed using steel sheet piling, diaphragm walls, contiguous bored piles, or ground freezing methods. This method is frequently used in tunnel excavation works.

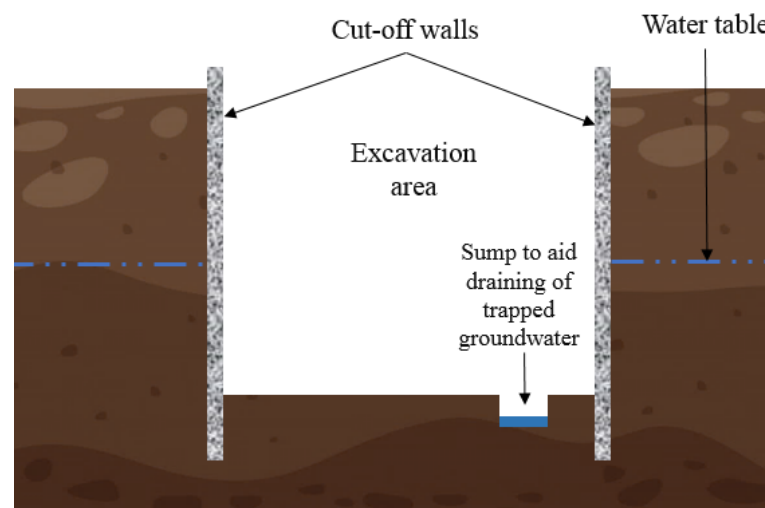


Figure 1.28 Exclusion method using cut-off walls*

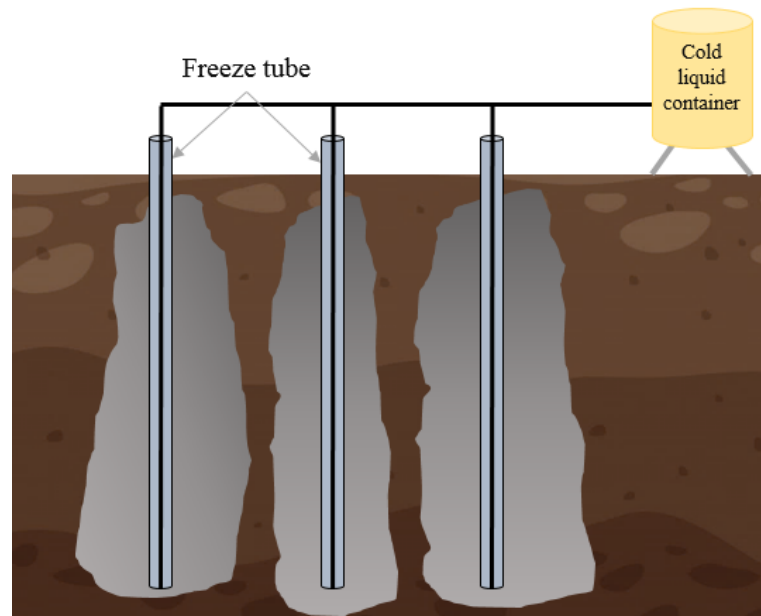


Figure 1.29 Exclusion method using ground freezing*

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TOPIC 2

FOUNDATION

INTRODUCTION

Sub-structure is a structure forming the foundation of a building or other construction. This includes foundations, ground beams, ground floor columns, and ground floor slabs.

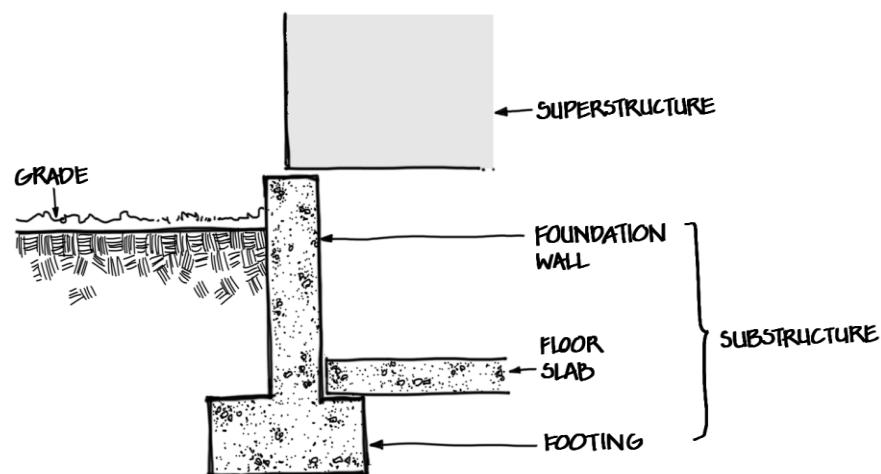


Figure 2.1 Sub structure and super structure*

Foundation is the base on which a building rests. This is to transfer the load of a building to suitable soil safely. There are several types of loading:

- dead load – concrete structure, walls, timber structure, roof covering & other permanent components of a building
- live load – non-permanent fixtures & fittings (tables, chairs, etc)
- wind load

DETERMINING FOUNDATION SYSTEM

There are three major factors:

- i. Type and bearing capacity of soil
- ii. Building design
- iii. Types of foundation

COHESIVE SOIL

It is fine grained particles that are closely integrated and stick together. The particle size ranges between 0.06mm or less. The level of cohesiveness depends on the size, shape and water level. When it's wet, it is soft, and when it's dry, it becomes hard. It has a high level of moisture content and always experiences shrinkage and extension processes. The increasing water level can cause soil strengths to differ. Therefore, the foundation depth should be at least one meter from the earth's surface. A high level of water content can cause difficulty in earth excavation, flooding the construction site, e.g., clay and silt.



Figure 2.2 Sand, silt, and clay

NON - COHESIVE SOIL

The soil particles do not stick to each other, and the particle size ranges between 0.06mm to 200mm. Non-cohesive soils have high value for a construction site. Water is easy to flow out because of its hollow particle. E.g., gravel and sands.



Figure 2.3 Gravel

FOUNDATION TYPES

- i. Deep Foundation: Transfer load to subsoil some distance below the ground floor of a building. Depth > 3m below finished level. E.g: Pile
- ii. Shallow Foundation: Transfer load to subsoil at a point near to the ground floor of a building. E.g.: Strips, Raft, Footing.

Strip Foundation

It is a continuous strip of concrete that provides a continuous ground bearing under the load bearing walls. It is placed centrally under the walls and composed of plain concrete to a mix of 1:3:6 by volume. The thickness shall not be less than 150mm and can be for buildings up to 4 stories high.

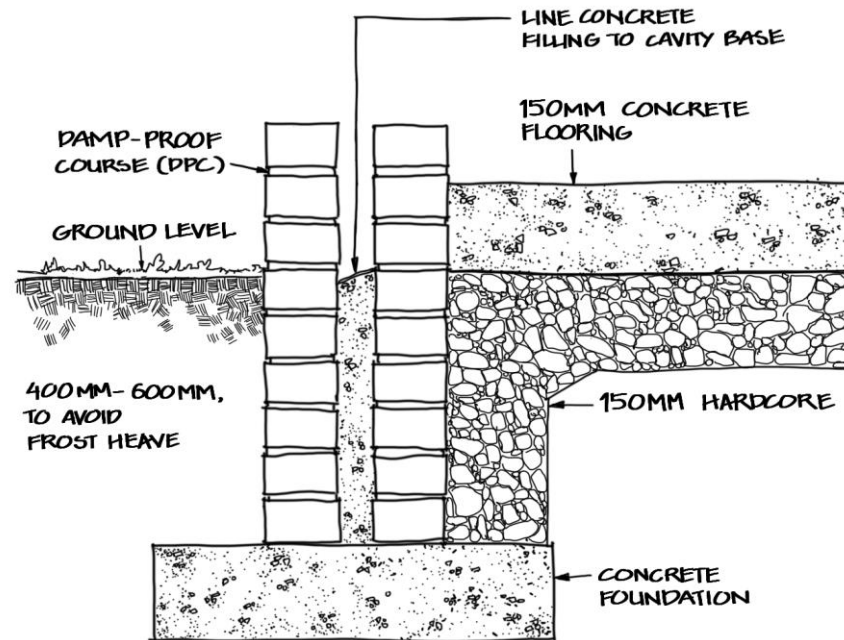


Figure 2.4 Strip foundation*

Trench Foundation

This is more economical than strip foundation to a depth of 900mm or more shrinkable in clay soil and brickwork below ground. Quantities of excavation, backfill, and surplus soil removal were reduced when the width of the trench is reduced. A deeper foundation provides greater resistance to fracture from an unequal settlement. It is timesaving because of the quicker completion with concrete trench fill.

CONSTRUCTION SEQUENCE FOR
TRENCH FILL FOUNDATION:

1. DIG OUT TRENCH
2. LAY & SET CONCRETE TRENCH
FILL FOUNDATION
3. BRICKWORK LAID ON OUTER LEAF
UP TO DPC (DAMP PROOF COURSE)
4. LAY BLOCKWORK ON INNER LEAF (UP TO DCP)
5. BACKFILL TRENCH
6. APPLY DPC (DAMP PROOF MEMBRANE) TO
BOTH INNER & OUTER LEAVES
7. CONTINUE BUILDING BRICK/BLOCK WALLS

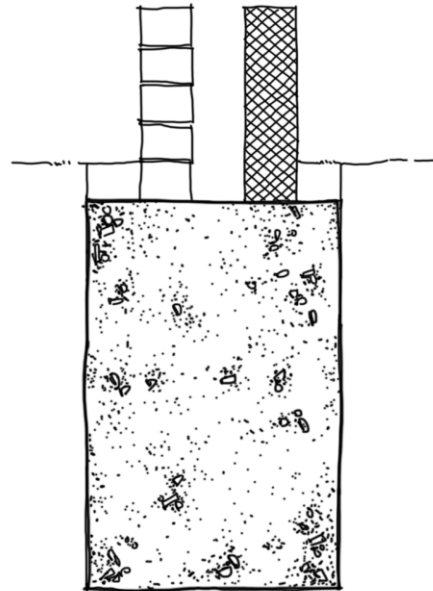


Figure 2.5 Trench foundation*

Pad Foundation

This is to support and transmit loads from piers and columns. Concrete grade type of 1:2:4 is used. The most economic plan shape is square. The thickness shall not be lesser than the projection from the column or 150mm. The size of the foundation can be reduced by adding steel reinforcement towards the bottom of the foundation, running it in both directions.

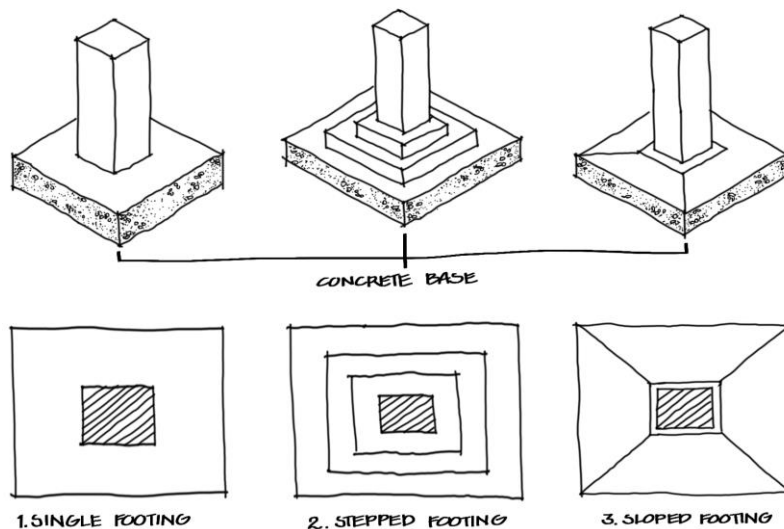


Figure 2.6 Pad foundation*

Raft Foundation

It covers the whole area of the building and usually extends beyond it. RC slab is up to 300mm thick; thicken under a load-bearing wall. Best suited for use on soft natural ground or mining areas and used when columns or other structural loads are close together. It acts as a single unit, thus eliminating differential settlement. However, it is expensive. There are ways to protect the raft; by laying concrete paving around the building, deepening the edge beam, and laying a field drain in a filled trench.

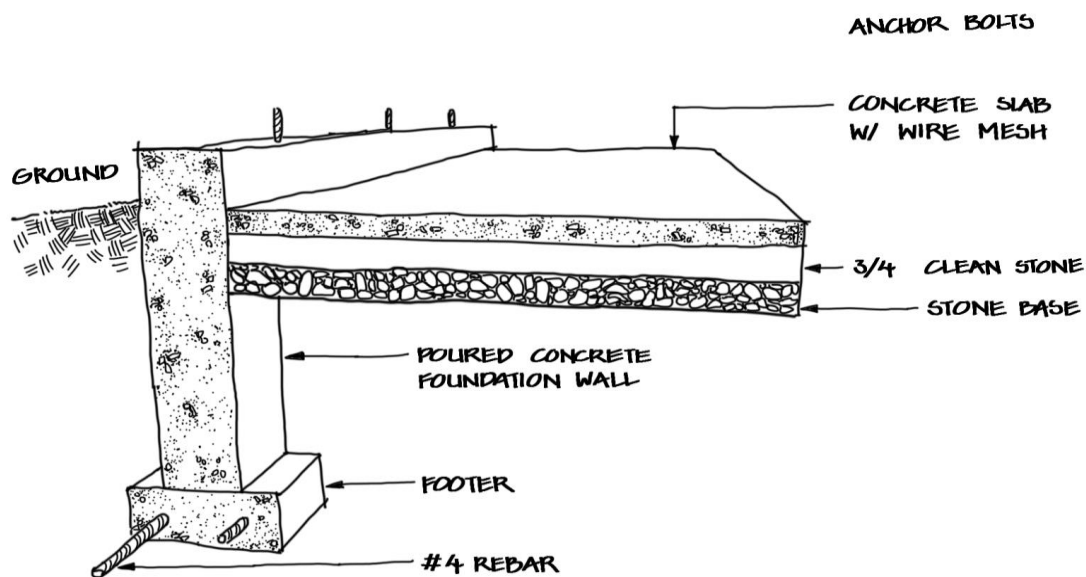


Figure 2.7 Raft foundation*

The usage of raft foundations is when the structural loads are high, or the soil condition is so poor that spread footings would be exceptionally large. As a rule of thumb, if spread footings covered more than 50% of the building footprint area, a mat or some type of deep foundation usually would be more economical. When the soil and structural loads are very erratic, it is prone to excessive differential settlements. The structural continuity and flexural strength of a mat will bridge over these irregularities. The lateral loads are not uniformly distributed through the structure and thus may cause differential horizontal movements. Lastly, when the bottom of the structure is below the groundwater table, waterproofing is a paramount concern. Rafts are monolithic, and they are much easier to

waterproof. The weight of the mat also helps resist hydrostatic uplift forces from the groundwater.

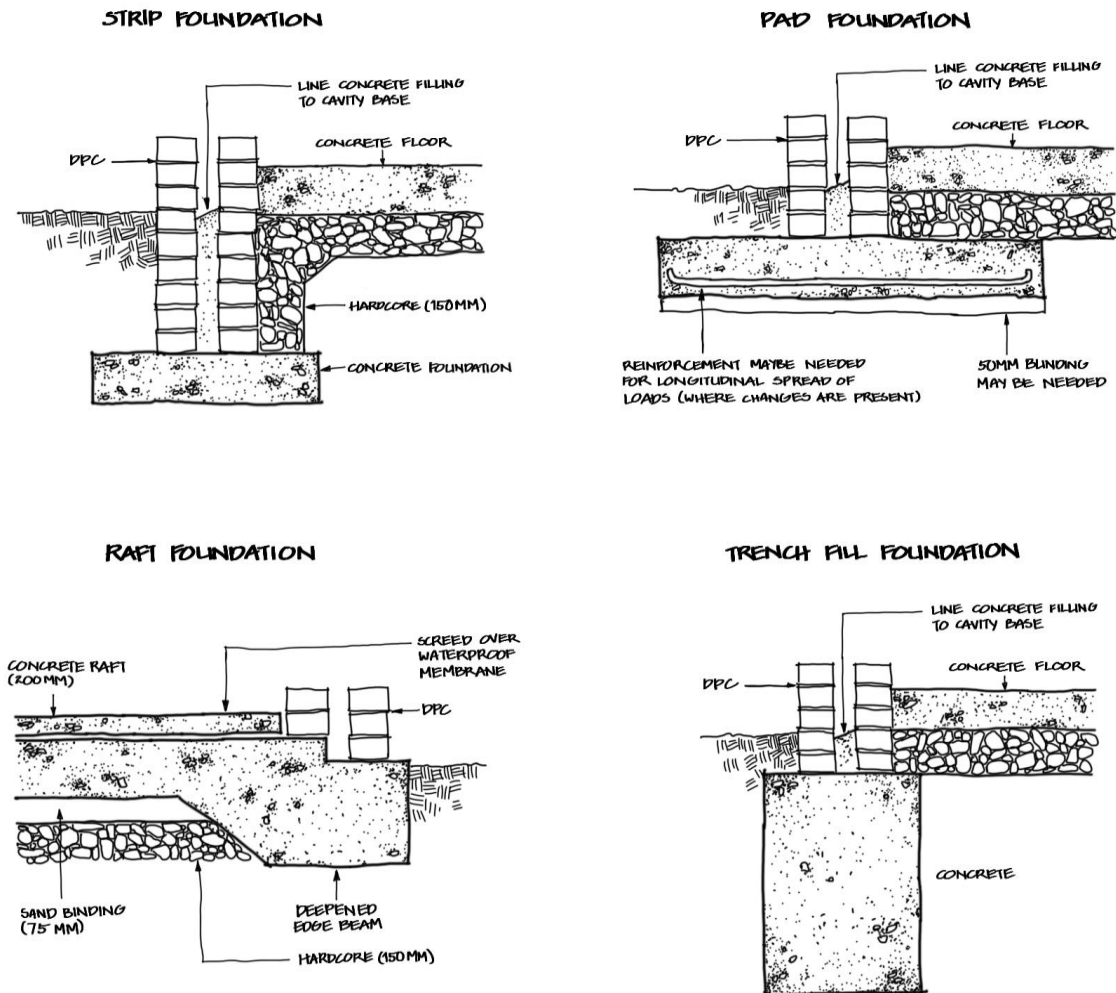


Figure 2.8 Shallow foundation*

Pile Foundation

Pile foundation is a group of piles that support a superstructure, typically used in multi-storey buildings. This is to transmit load through weak and unstable soil conditions. Pile foundation comprises piles and pile caps. A pile cap will connect the pile and distribute the superstructure loads to the layer beneath it. Pile is a load-bearing member made of timber, steel, concrete, or a combination of these materials. It is usually forced into the ground to

transfer the load to underlying soil or rock layers when the surface soils at a proposed site are too weak or compressible to provide enough support.

- *End Bearing Pile Foundation*

The shaft passes through soft deposits. The base rests on bedrocks / penetrates dense sand/gravel. Pile acts as a column.

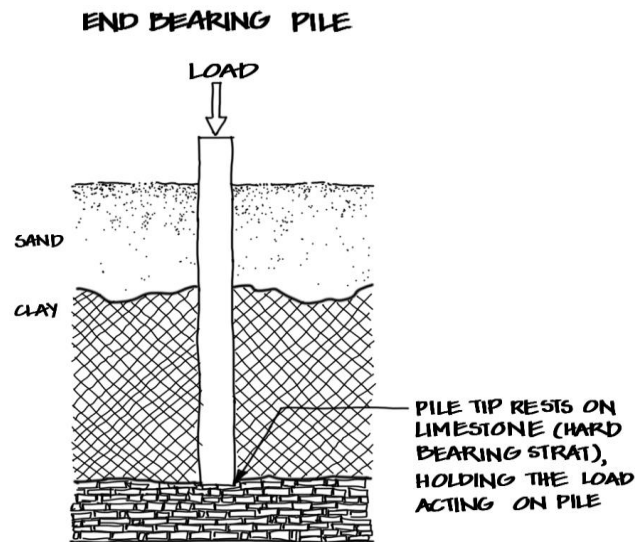
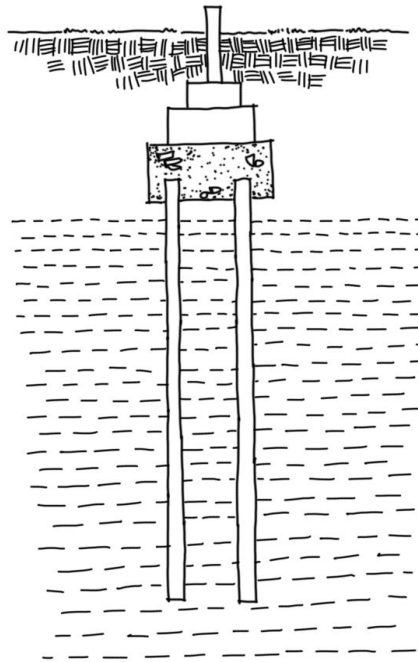


Figure 2.9 End bearing pile*

- *Friction Pile Foundation*

It is embedded in cohesive soil, often firm clay soil. It obtains its support mainly by the adhesion or 'skin friction' of the soil on the surface of the shaft. The load is transferred to the adjoining soil by friction between the pile and the surrounding soil.



FRICTION PILE

Figure 2.10 Friction pile*

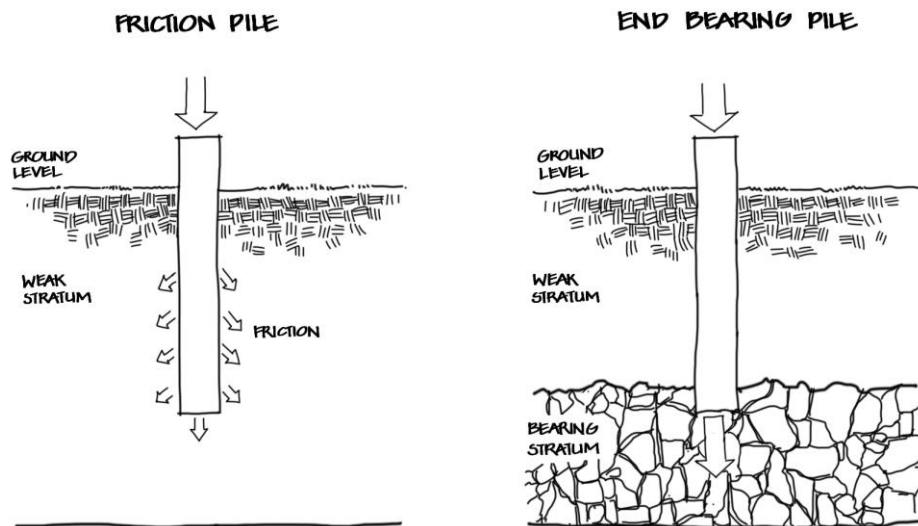


Figure 2.11 End bearing and friction pile*

- *Combination Pile Foundation*

A pile may pass through a fairly soft soil that provides frictional resistance and then into a firm layer which develops a load-carrying capacity by both ends bearing and friction over a relatively short length of embedment.

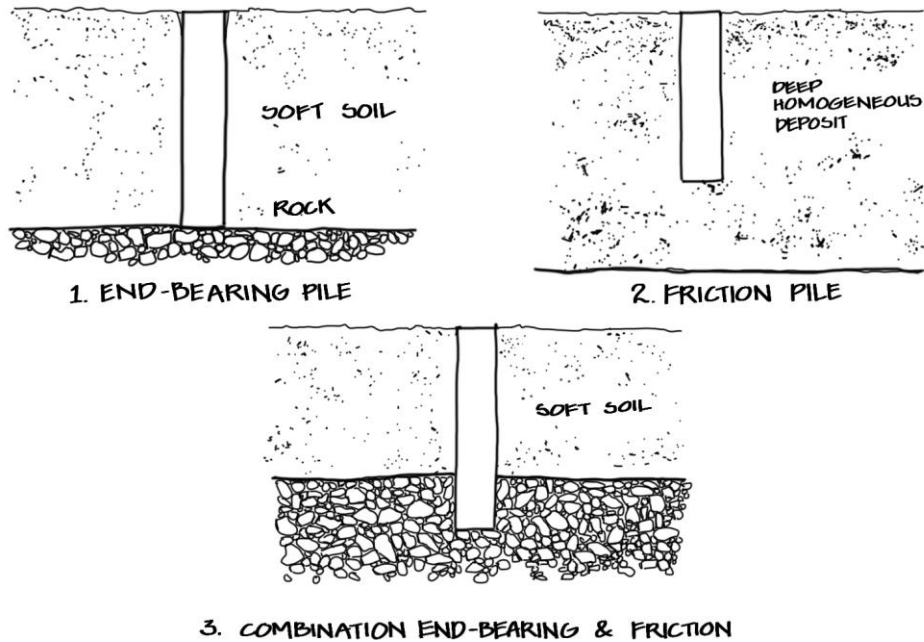


Figure 2.12 Combination pile*

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* Sr Azrina Md Yaakob

TOPIC 3

FLOOR

INTRODUCTION

Floor is described as the lower enclosing surface of spaces within buildings. Floors can be categorised into ground floor and upper floor. Each of the categories has different functions.

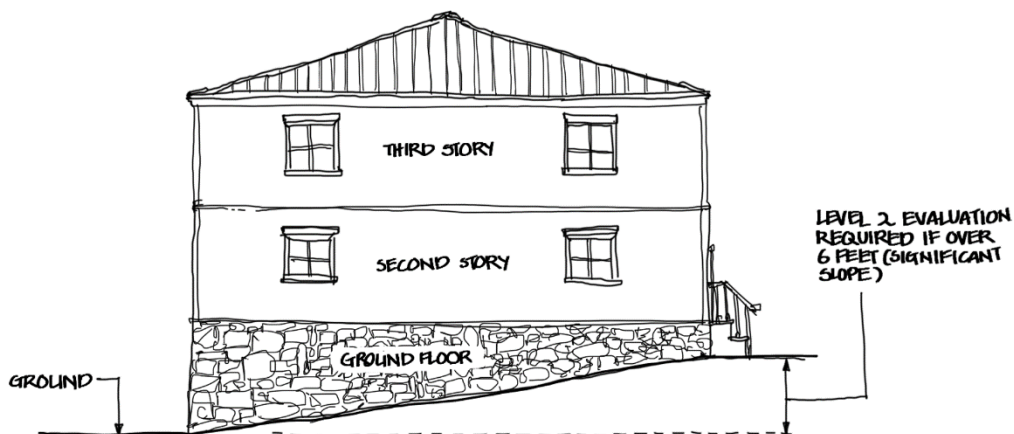


Figure 3.1 Typical illustration of ground floor and upper floors*

The functions of ground floor in buildings are:

- i. To withstand load imposed upon them, dead and live load.
- ii. To prevent the growth of greens inside the building with concrete over-site.
- iii. To prevent penetrating damp into the building – damp proof membrane.
- iv. To reduce the amount of maintenance or replacement work to a minimum.
- v. To provide an acceptable finish, meeting the needs of users.

The functions of upper floors in buildings are:

- i. To provide support for their weight, ceilings and superimposed loads
- ii. To restrict the passage of fire for high-rise buildings
- iii. To restrict the transmission of sound from one floor to another
- iv. To provide durability
- v. To bridge the specific span economically and be capable of quick erection
- vi. To accommodate services
- vii. To provide acceptable finish, meeting the needs of users.

FUNCTIONAL REQUIREMENTS

There are four vital functional requirements for any types of floors, which are described as follows:

| Strength & Stability | Durability & Damp Prevention | Heat Insulation | Sound Insulation & Fire Resistance |
|--|--|--|--|
| Floors of any type should be strong enough to withhold and support any floor coverings and superimposed loads. | Floors should be able to provide impervious, smooth, clean, durable and wear-resistance surface. | Floors (ground floor and basement floor) need to have insulation against heat especially for suspended and ventilated timber floors. | Sound and fire resistance need to be provided especially for upper floors. It acts as sound and heat barriers in vertical direction. |

Figure 3.2 Functional requirements for any types of floors

COMPONENTS OF FLOOR

The construction of ground floor comprises four important components, namely:

- i. Hardcore
- ii. Blinding
- iii. Damp Proof Membrane

iv. Concrete Floor Slab

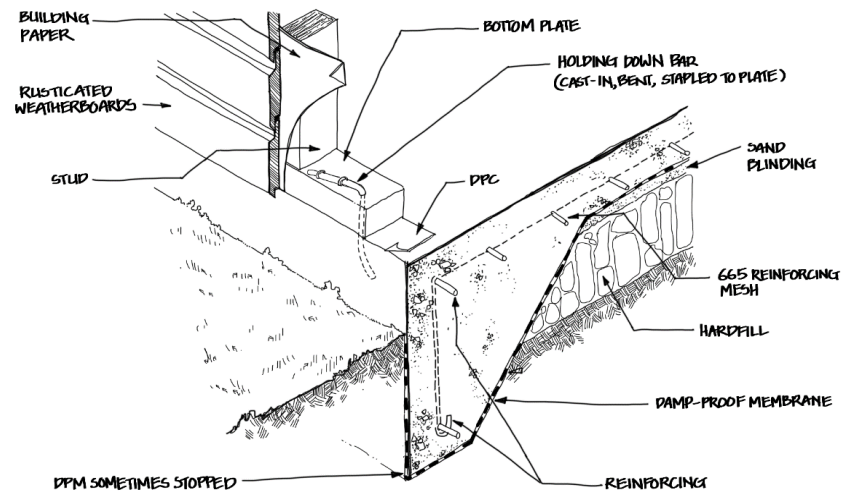


Figure 3.3 Typical illustration on ground floor slab*

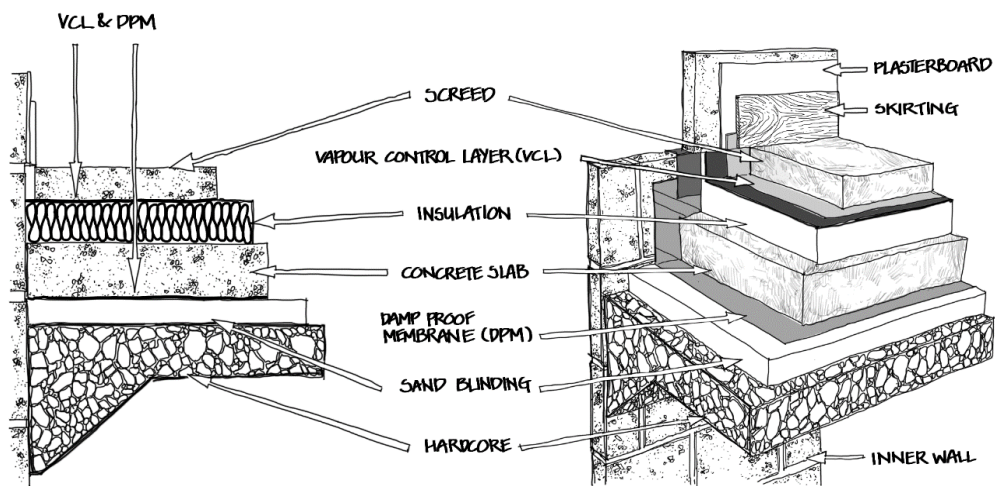


Figure 3.4 Solid ground floor slab*

HARDCORE

The hardcore function is to fill hollows and raise the finished level of an over-site concrete slab after turf removal. It is also to provide a firm working surface and prevent contamination of the lower part of wet concrete. It reduces the amount of rising ground moisture. It is hard, durable and chemically inert; will not attack concrete and mortar; readily be placed in a compact and dense condition. Thickness of hardcore ranges between 100mm – 150mm

BLINDING

The function of blinding is to even off the hardcore surface, if a damp-proof membrane is to be placed under the concrete bed. A layer of sand; within 25mm – 50mm thick.

DAMP PROOF MEMBRANE (DPM)

To prevent dampness from getting through a ground bearing concrete floor. The floor should be protected by an impervious layer, usually a 1200 gauge (0.3mm) heavy duty polythene damp-proof membrane. The DPM can be positioned either on the sand blinding or on the concrete slab. Polythene DPM joints should be weltd or taped and overlapped by at least 300mm. The DPM must be linked with the Damp Proof Course (DPC) in the walls to ensure that the entire building's interior is protected from moisture through a continuous and impervious barrier.

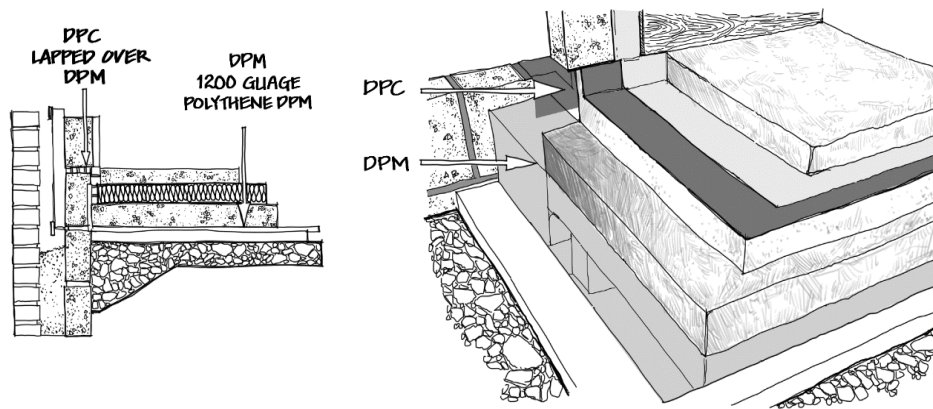


Figure 3.5 Damp proof membrane*

CONCRETE FLOOR SLAB

A typical concrete mix for a ground bearing slab is 1:2:4 mix. The floor slab is usually placed over the DPM. The floor slab should not be less than 100mm thick. It is important to ensure all services and ducts running under the floor are installed and tested before pouring concrete over the slab. If required, the concrete slab may be reinforced with a layer of steel mesh. Once the concrete has been poured over, it can be tempered with a heavy beam to remove air and surplus water to ensure a level surface slab. The concrete slab should be left to dry out for around two to three days.

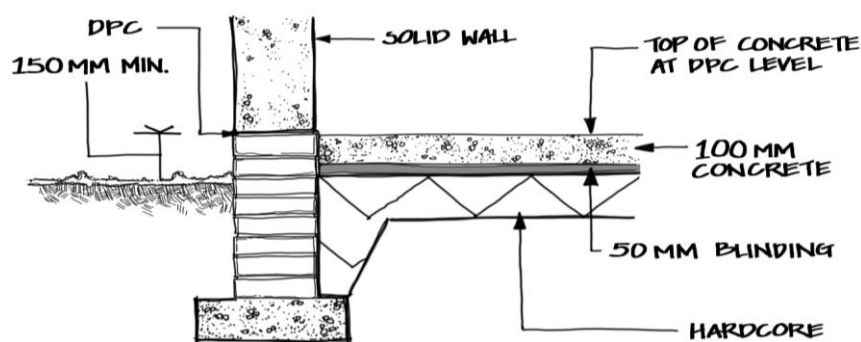


Figure 3.6 Concrete floor slab with blinding and hardcore*

Construction of Ground and Upper Floor Slab

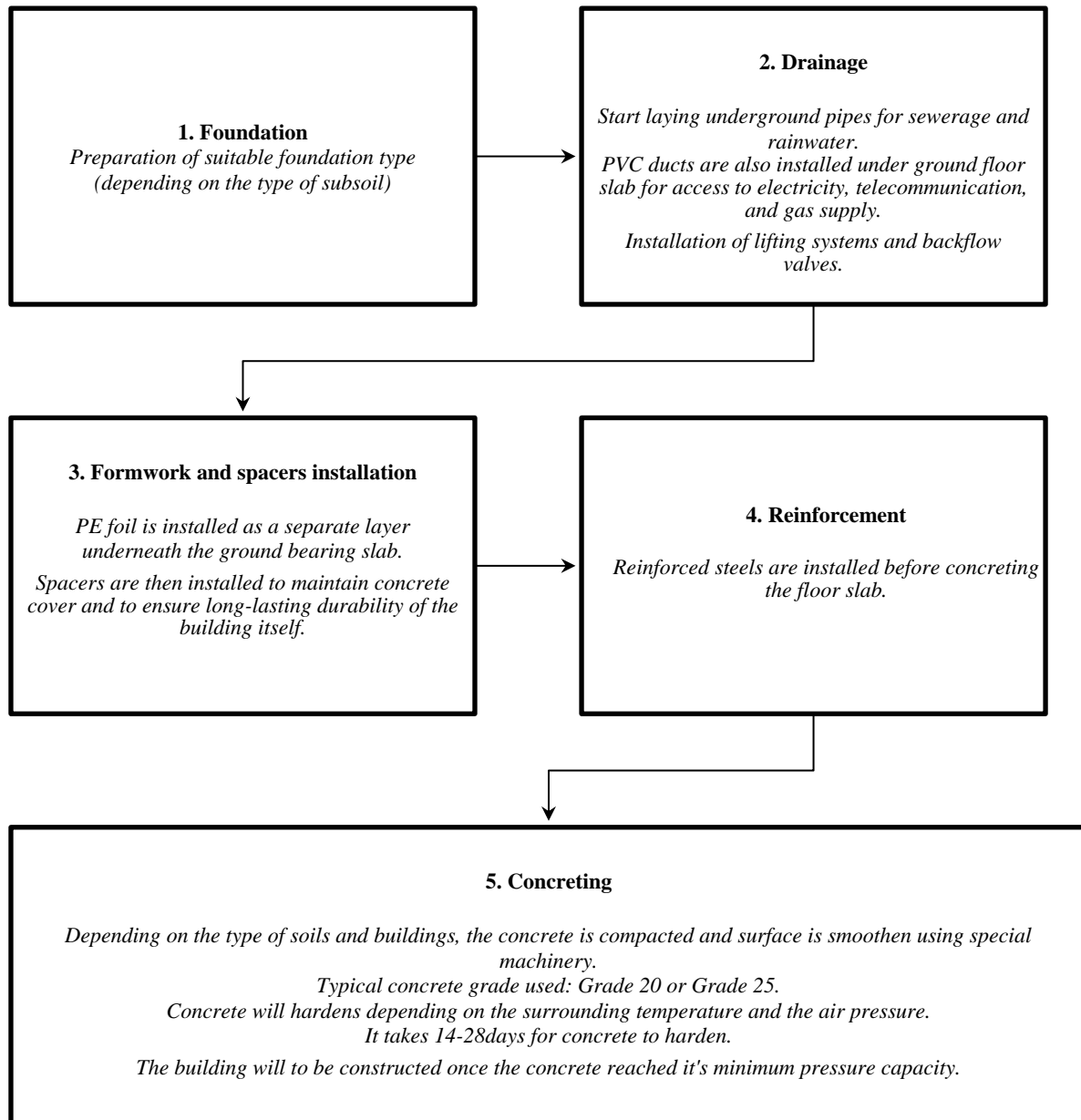


Figure 3.7 Construction flow of slab

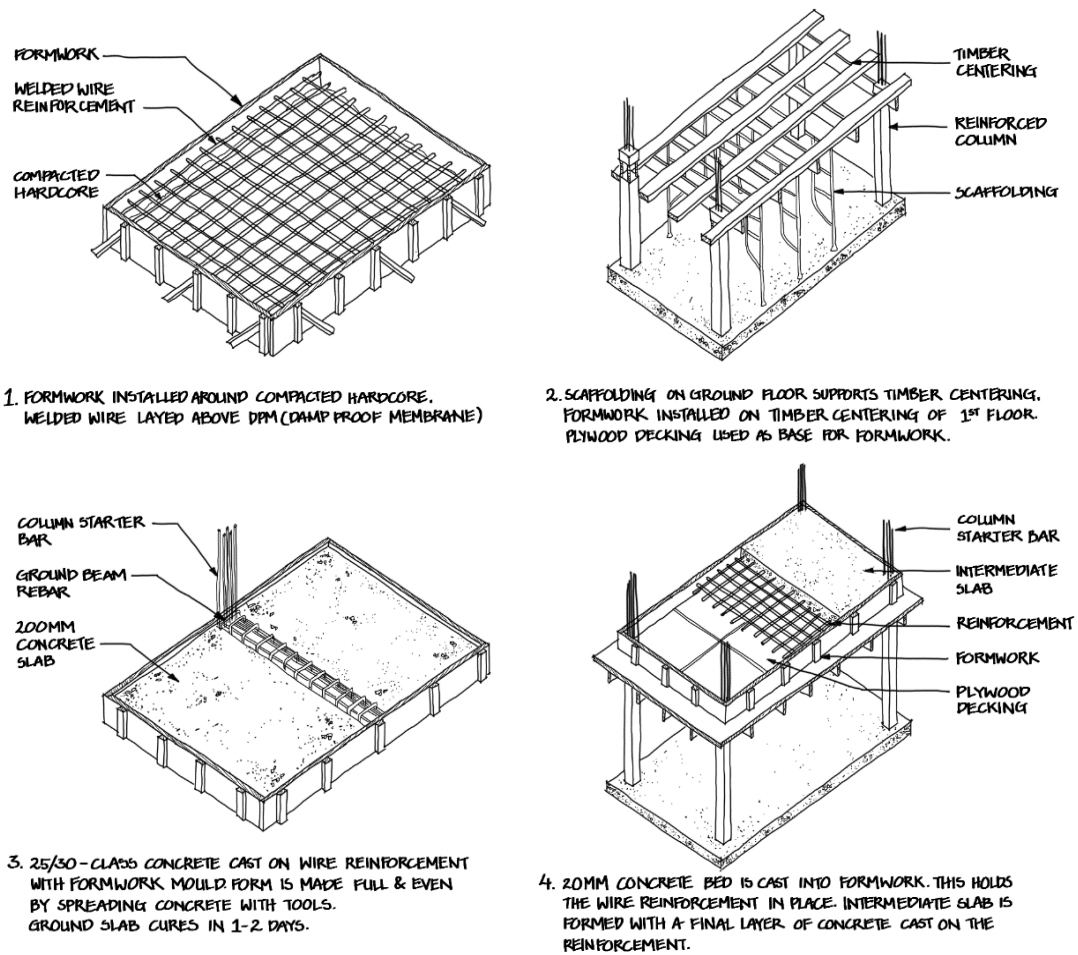


Figure 3.8 Typical illustration of the floor slab construction*



Figure 3.9 Construct columns



Figure 3.10 Construct slab



Figure 3.11 Concreting

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TOPIC 4

FRAME

INTRODUCTION

Frame components consist of columns and beams to make up the structure of the buildings. It becomes a part of superstructure elements in a building. The primary function of structural frames is to carry the total loads of the building and transfer them to the foundation. Many types of frames vary in the construction materials in which they are built.

FACTOR TO BE CONSIDERED FOR SELECTION OF MATERIALS

Certain factor needs to be considered during selection of materials to ensure that the structural frame functions properly. The factors are:

- i. Span of roof
- ii. Number of floors
- iii. Safety aspects
- iv. Cost and client's cash flow
- v. Buildability
- vi. Purposed used of building
- vii. Availability of materials during construction
- viii. Maintenance requirements
- ix. Client requirements

FRAME COMPONENTS

The frame structure of the building consists of several members, namely as column, beam, and slab.

COLUMN

Columns are defined as vertical load-bearing members carrying loads and transmitting the beam loads down to the substructures. Accordingly, structural continuity needs to be provided to reinforce the columns, as columns are usually constructed for story height (Chudley and Greeno, 2014).

BEAM

The beam is a horizontal load-bearing member where it can be classified as either main beams or secondary beams. Main beams mean the capability of the beams to transmit floor and secondary beam loads to the columns. Meanwhile, secondary beams mean the capability of the beams to transmit floor loads to the main beams.

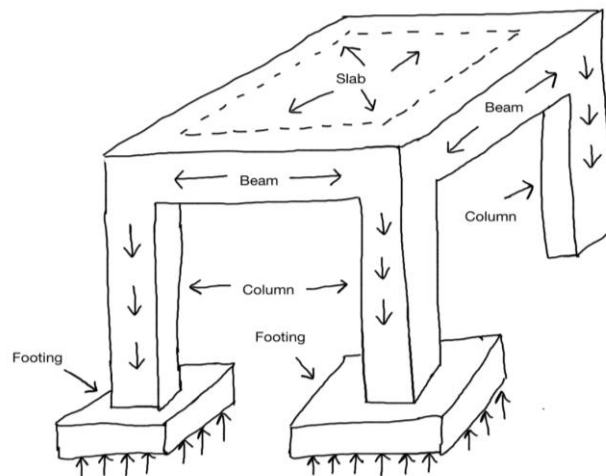


Figure 4.1 Component of frame- column and beam*

TYPE OF FRAMES

There are several types of frame available in our industry which depends on its materials. The materials chosen as the structural frame of one building will depend on several factors, as stated in figure 4.2 below shows the type of frames in the construction industry

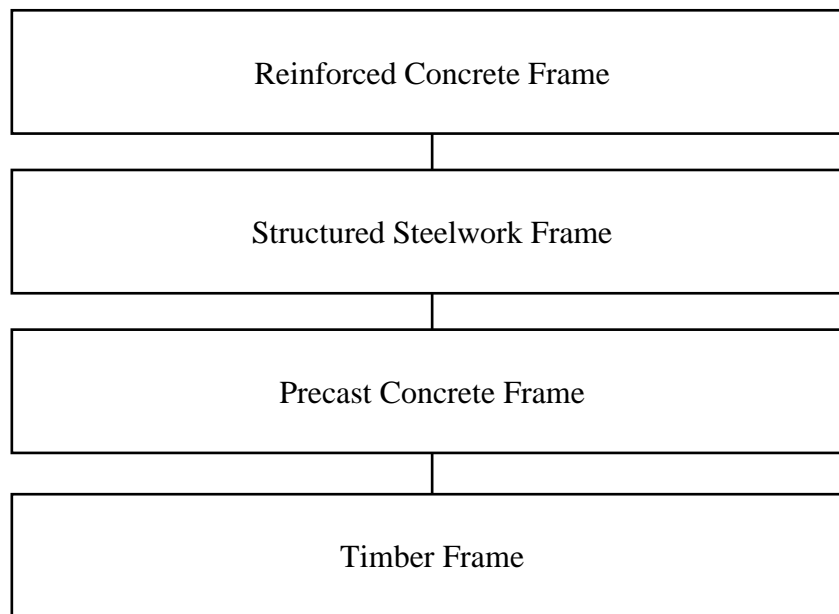


Figure 4.2 Types of frames in the construction industry

The following section will discuss frames based on their materials built to ease the differences between each of the frame characteristics and features.

REINFORCED CONCRETE FRAME

As known, concrete is a material with little tensile strength that needs to be strengthened with reinforcement bars. The function of reinforcement bars is to resist the induced tensile stresses which can exist in tension or diagonal tension. The calculation for reinforcement required according to the area, diameter, type, or position will be calculated by a certified civil engineer. The reinforcement bar used as main bars in structural members is divided into high tensile reinforcement bars and mild steel reinforcement bars.

REINFORCED CONCRETE COLUMN

A column is a vertical member carrying the beam and floor loadings to the foundation and is a compression member. As concrete is strong in compression, it may be concluded that if the compressive strength of the concrete is not exceeded, no reinforcement will be required. For this condition, there are requirements to meet:

- i. Column must be short (ratio height to thickness does not exceed 12 according to BS8110-1, Section 3.8.1.6)
- ii. Cross-section of the column must be large
- iii. Loading must be axial

However, these conditions rarely occur in framed buildings where bending is induced, and the reinforcement needed to provide tensile strength is apparent. Chudley and Greeno (2014) stated that the minimum number of main bars in a column should not be less than four for rectangular columns and six for circular columns with a minimum of 12mm diameter and a total cross-sectional area of not less than 0.8%. All reinforcement bars should be tied by a link passing around the bar in such a way that it tends to move the bar towards the center of the column. The arrangements are shown in Figure 4 below.

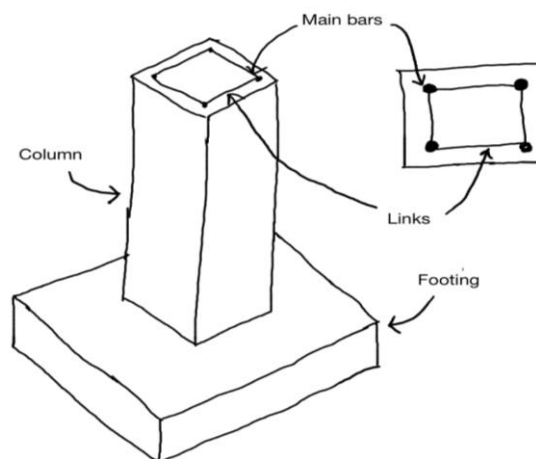


Figure 4.3 Reinforced concrete column*

Construction Method of Reinforced Concrete Column

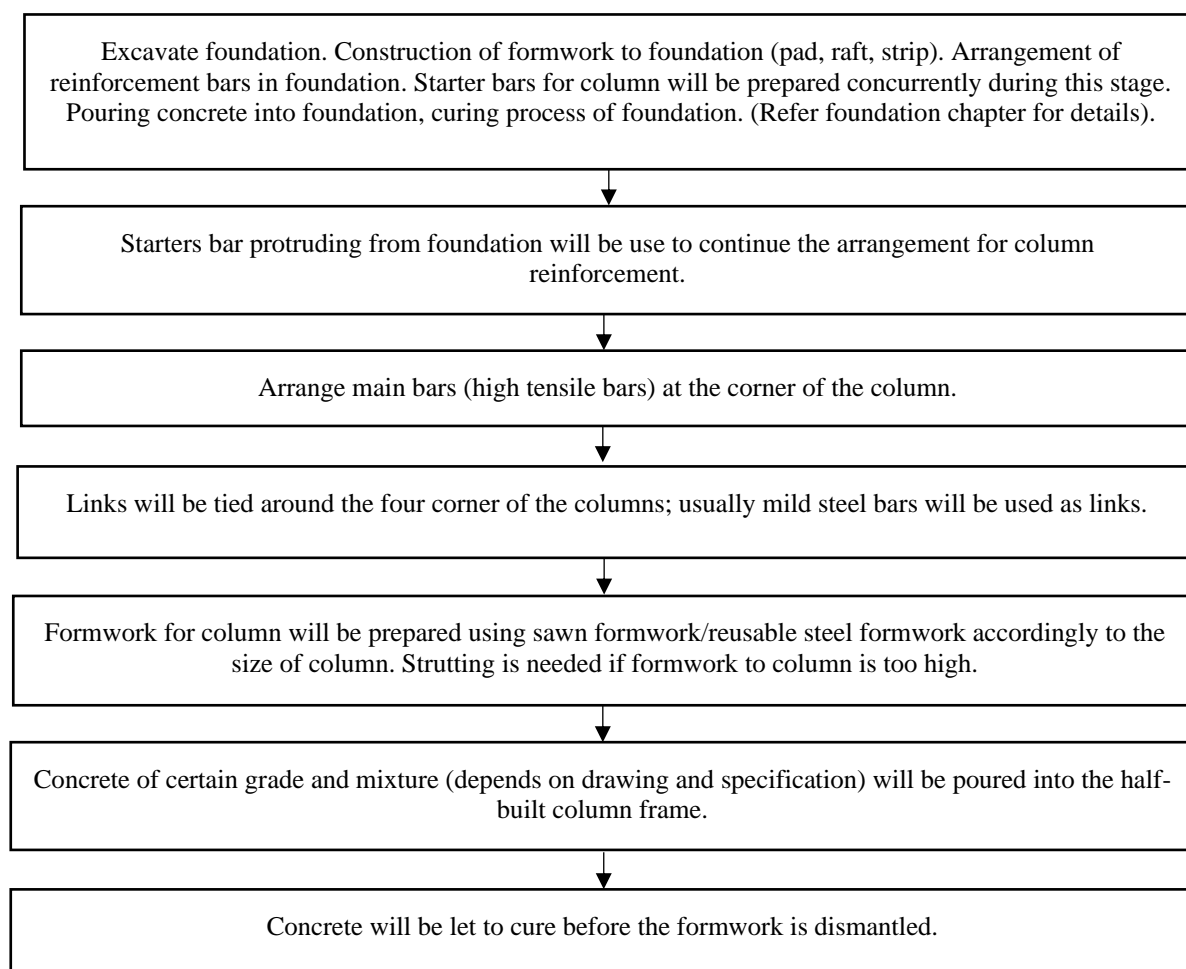


Figure 4.4 RC Column construction sequence

REINFORCED CONCRETE BEAM

As for the beam component, when the beam is imposed on loads, the beam will: i) shear at/near the support or along its length and ii) deflect/bend due to tension and compression. The correct design of the reinforced concrete beam will ensure that the beam has sufficient strength to resist both the compression and tensile forces encountered in the beam. Therefore, reinforcement is needed to resist shearing force by either having stirrups or

inclined bars, or both. On top of that, stirrups or binders are provided in the beams to minimize shrinkage cracking and form a cage for easy handling.

Figure 4.5 below shows the behaviour of beam bending. The beam spans between two simple supports carrying a uniformly distributed load and tend to bend in the centre. There are three characteristics in bending of a beam that is important in design considerations which are:

- i. The deflection that occurs of the span of the beam
- ii. Tension forces set up in the lower half of the beam
- iii. Compression forces set up in the upper half of the beam

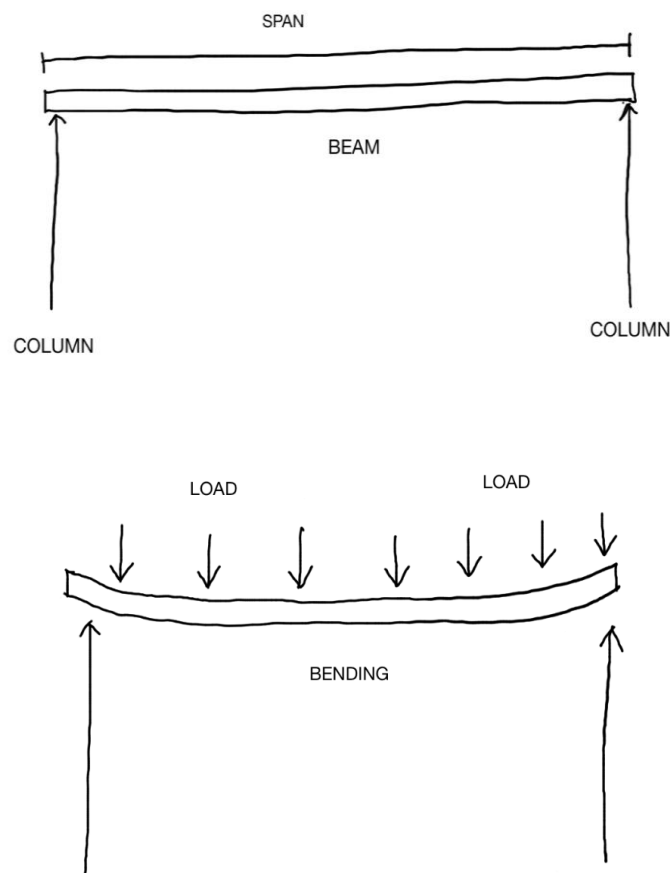


Figure 4.5 Behaviour of beam bending*

Construction Method of Reinforced Concrete Beam

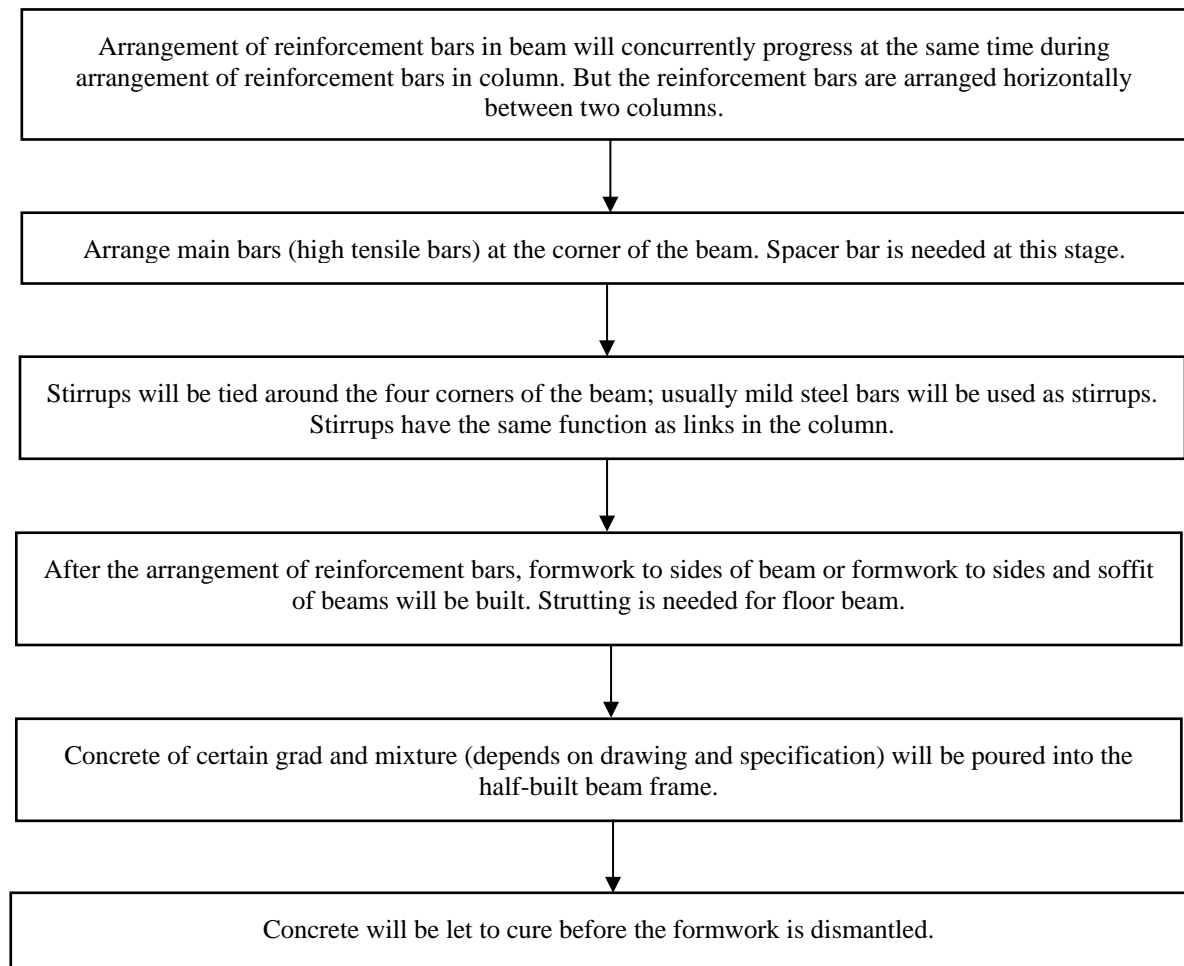


Figure 4.6 RC Beam construction sequence

STRUCTURAL STEELWORK FRAME

Steelwork frame is also known as steel portal frame. This method of building and designing simple structures primarily using steel or mild steel I-section for economic purposes. Steel portal frames are widely used in industrial, warehouse, and large retail buildings.

Type of Span

Accordingly, there are three types of spans for steel portal frames:

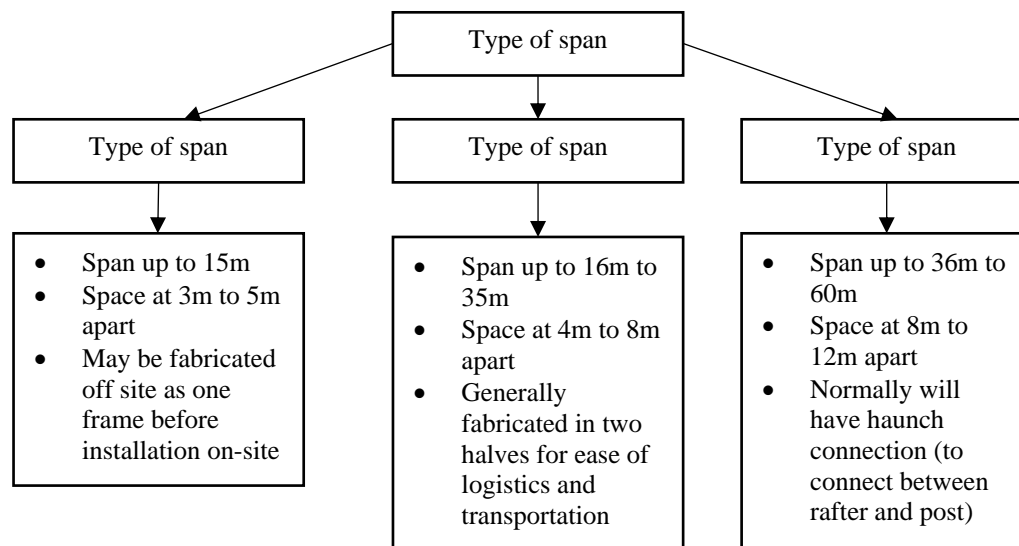


Figure 4.7 Types of spans in steelwork frame

Type of Portal Frame

If the frame exceeds 4m in height and 15m in span, the introduction of a hinged or pin joint at the base should be considered. A hinge is a device that allows free rotation to take place at the fixing point but at the same time will transmit both load and shear from joints and non-rigid joints. There are three basic forms of the portal frame using hinges at the base connections:

i. Rigid or fixed portal frame

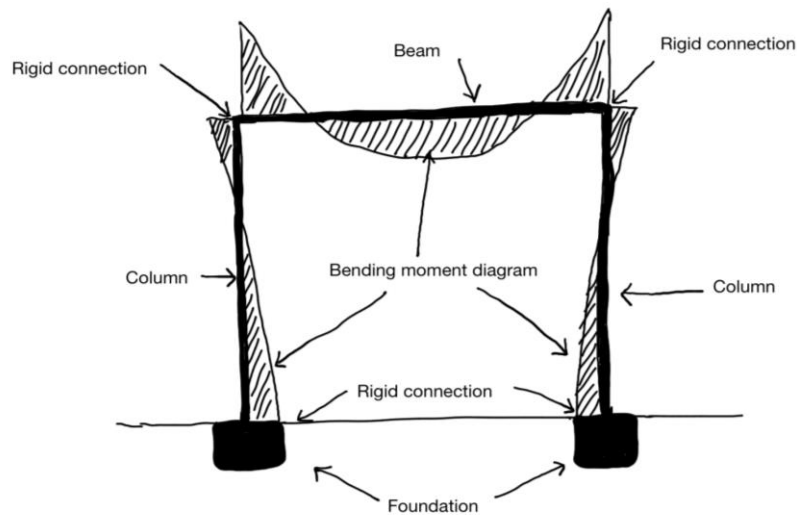


Figure 4.8 Rigid/ fixed portal frame*

Also known as whole frame action. All joints are fixed and the bending stresses from the roof are also transferred to the foundations. The bending stresses are effectively carried by three members which are roof beam, columns, and foundations. The three members act as one integrated structural element.

ii. Two-pin portal frame

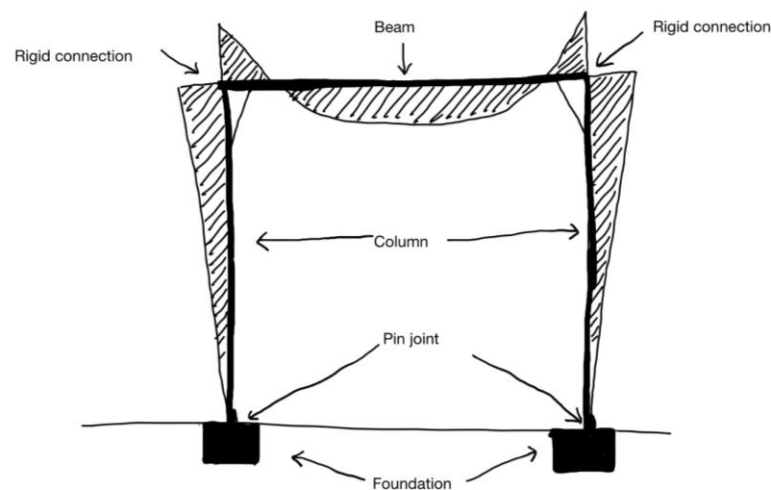


Figure 4.9 Two-pin portal frame*

In a two-pin portal, the connections between the columns and the roof beams are rigid, including the ridge's connection. The connection from columns to foundations is pinned and movement is permitted at this connection. The bending stresses are not transferred to the foundations. Therefore, foundation design is simple since bending moments do not need to be accommodated.

iii. Three-pin portal frame

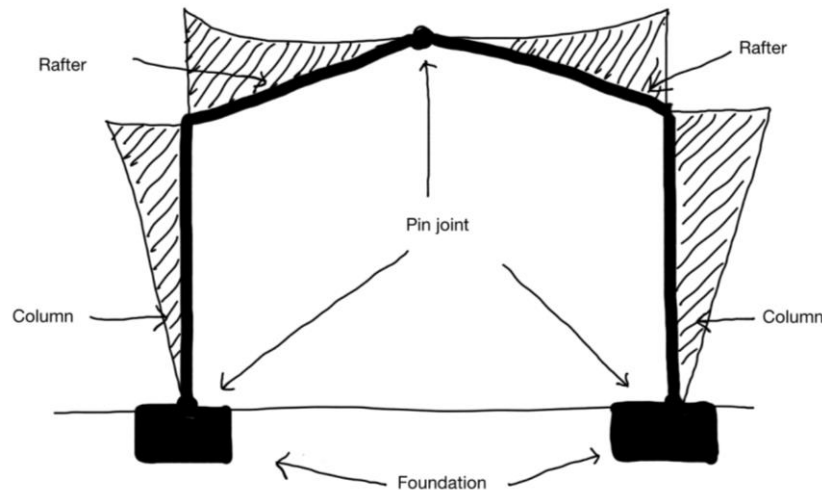


Figure 4.10 Three-pin portal frame*

In three pin portals, the only rigid connection is between the columns and the roof beam. In essence, one-half of the portal is propped by the other half. The bending moments are now carried only by the columns and beam on each half of the portal and the three must be heavier than two pin portals. Three-pin portal frame allow differential movement at the pinned connection between columns and foundations and connection at the ridge

Construction Method of Steel Portal Frame

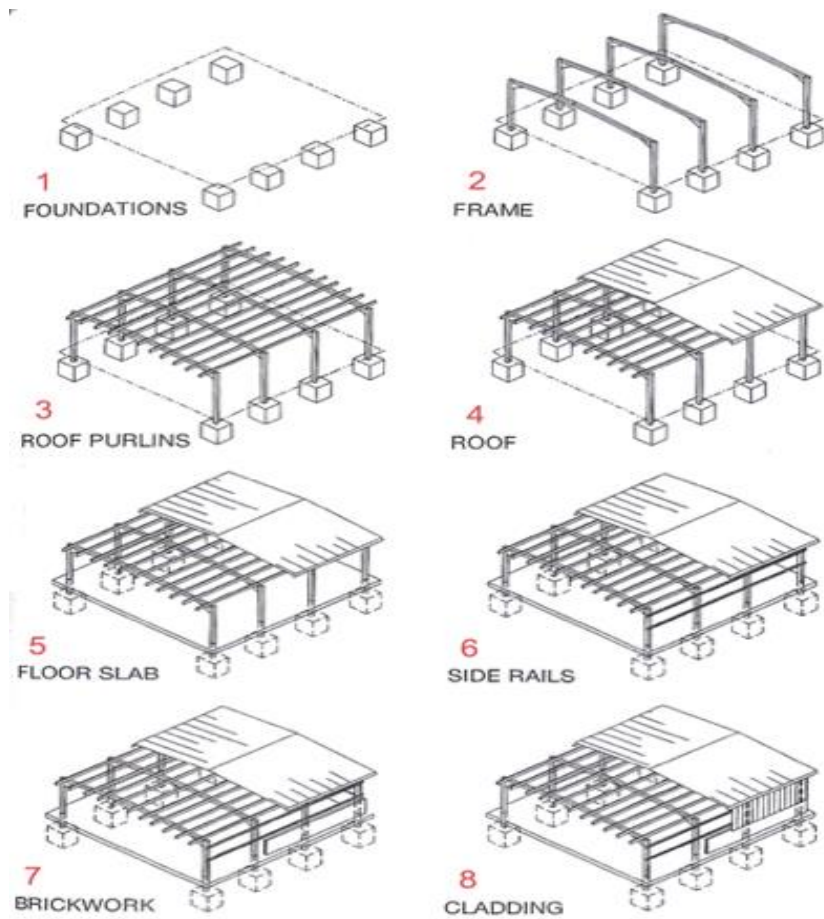


Figure 4.11 Sequence of steel portal frame construction method

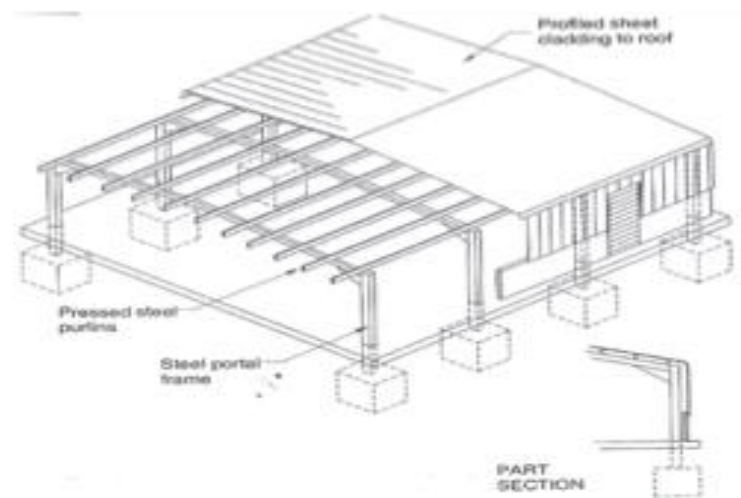


Figure 4.12 Steel portal frame building

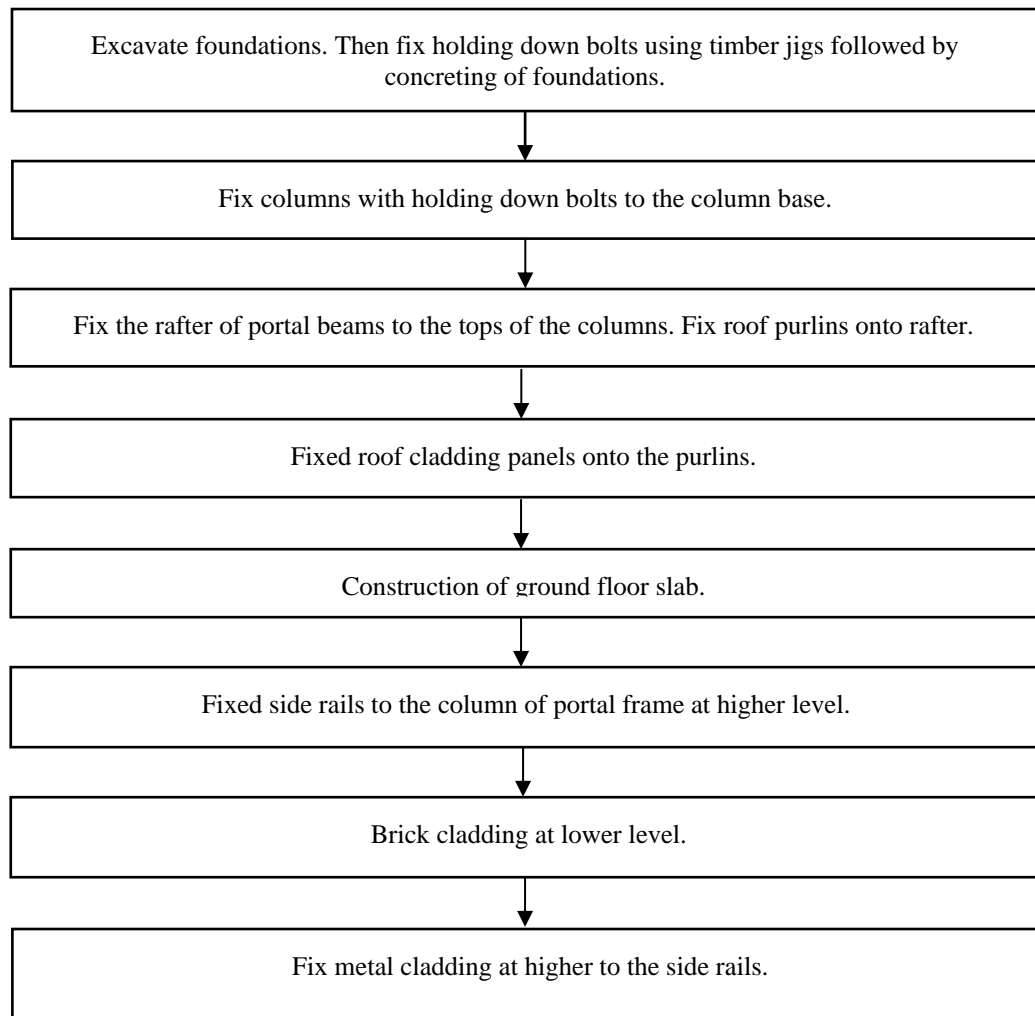


Figure 4.13 Steel portal frame construction sequence

Precast Concrete Frame

Precast concrete frames are produced as part of a 'system' building. Single and two-story buildings can also be produced as portal frames. Normally, reinforced concrete portal frames are used for warehouses, factories, and single-story buildings when there is a shortage of steel. Concrete portal frames are usually spaced from 4.5m to 6.0m apart to support precast reinforced concrete purlins and sheeting rails. Concrete portal frame bases are cast in concrete or strip foundations.

Type of Foundation Fixings for Precast Concrete Frame

The concrete portal frames can be connected to the foundation using the following methods:

- *Pocket connection*

The foot of the column is located in a pocket formed in the base and there is an all-round clearance of 25mm to allow final adjustment before the column is grouted into the foundation.

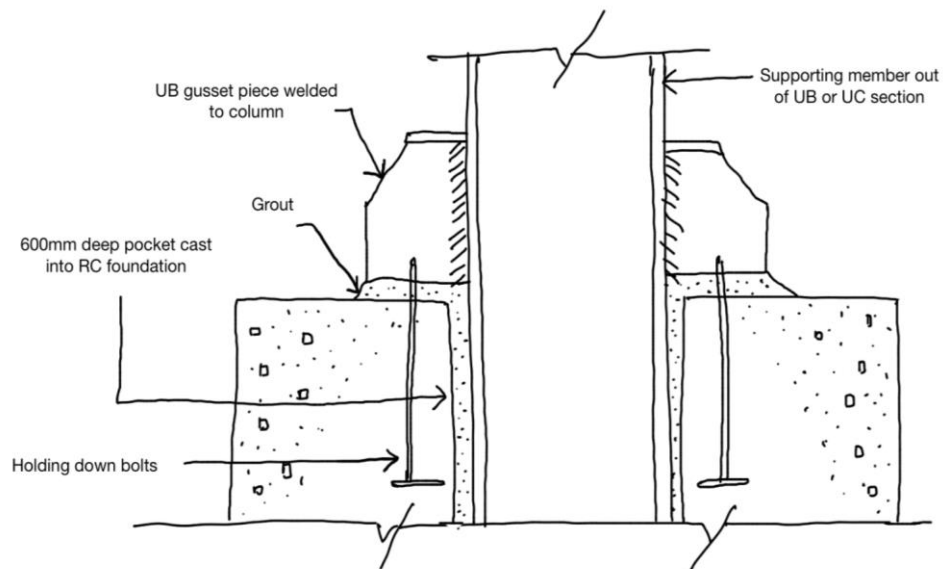


Figure 4.14 Precast concrete column to foundation connections*

- *Base Plate*

Connective base plate is cast or welded to the foot of the column and holding down bolts are used to secure the column to the foundation.

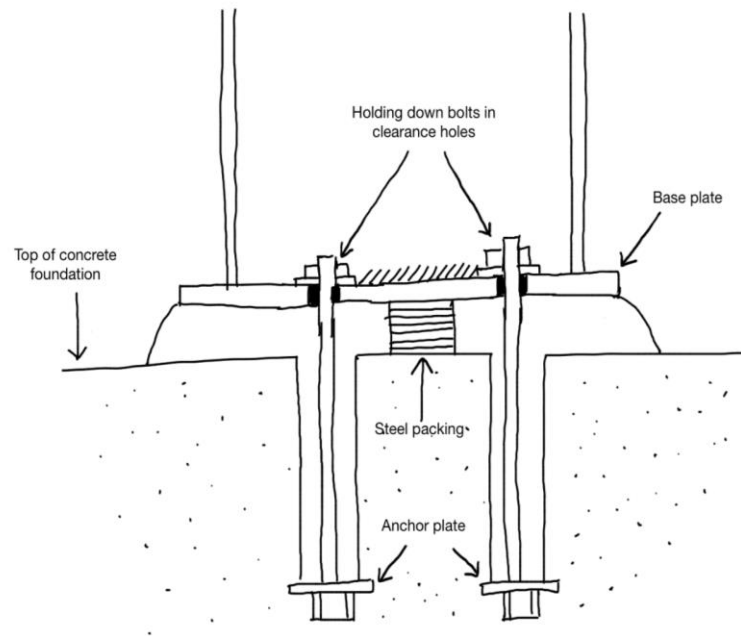


Figure 4.15 Precast concrete column to foundation connections*

- *Hinge Connection*

A special base or bearing plate is bolted to the foundation, and the mechanical connection is made when frames are erected.

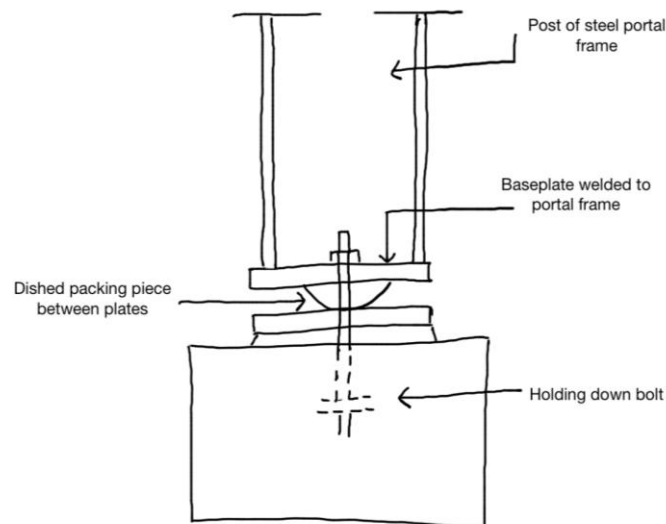


Figure 4.16 Precast concrete column to foundation connections*

Advantages of Precast Concrete Frame

- i. The precast concrete frame is an alternative to several materials in construction projects due to its benefits. The followings are the benefits of precast concrete application:
- ii. Minimal maintenance is needed for precast concrete frames unless the owner requires painting and cladding work
- iii. Fabrication by factory ensures a good quality product, accurately made, easy for assembly and minimal errors
- iv. Precast concrete with built-in natural resistance to fire, therefore no fire resistance treatment is required. Most precast frames of up to 24m spans have 1-hour fire resistance. Meanwhile, frame more than 24m are allocated with 2 hours of fire resistance
- v. Frames members are joined and connected using bolts and nuts. Therefore, the installation can be carried out quickly by semi-skilled labour
- vi. The clean lines of precast concrete portal frames are aesthetically pleasing
- vii. Setting out and construction for foundation design can be carried out by the portal frame sub-contracting firm

Disadvantages of Precast Concrete Frame

On top of its benefits, the precast concrete frame also has its limitation, which are:

- i. The component is very heavy, requires a large foundation, and is difficult to construct.
- ii. Due to the production is made in the factory, its bulky and heaviness required large transportation for logistic from the factory to a construction site
- iii. Require large cranes to allow for lifting of section at a construction site
- iv. Difficult to alter the existing building using a precast component
- v. Unattractive appearance due to its massive production from factory
- vi. Difficult to repair if the damage happened during installation.
- vii. Limited ranges of sizes

PRECAST SYSTEM IN MALAYSIA- INDUSTRIALIZED BUILDING SYSTEM (IBS)

In the Malaysian construction sector, Industrialised Building System (IBS) is defined as a construction system in which components are manufactured in factories, on or off-site, then transported, positioned, and assembled into a structure with minimal additional site works (IBS Survey CIDB, 2003). The precast system is a part of the IBS system in Malaysia. The other IBS Technologies includes formwork system, steel framing system, prefabricated timber framing system, blockwork system, and innovative on-site system. However, this chapter discusses the precast system related to frame only.

Industrialized Building System (IBS) – Precast Frame

According to CIDB (2011) in Industrialized Building System; People, Strategy and Process, the precast system is summarised as follow:

“Precast panels and building systems provide easy standardization, speedier construction, cost-effectiveness, high-quality finish, and enhanced façade design”

Precast concrete systems are more economical for high-rise buildings due to the repetitive nature of the design. Precast concrete construction involves precast elements, which has contributed significantly to the growth in infrastructure and social development projects. CIDB also classified Precast Concrete Framing, Panel, and Box Systems under Group 1, which includes precast concrete columns, beams, slabs, and walls. 3D-components comprise of balconies, staircases, toilets, lift chambers, box girders, and refuse chambers. Apart from lightweight precast concrete and permanent concrete works.

Industrialized Building System (IBS) – Precast Concrete Beam

As stated in *IBS Catalogue for Precast Concrete Building System* (CIDB, 2017), the precast concrete beam can support the self-weight of the floor slabs alone while resisting all possible load combinations during precast construction such as torsion. Accordingly, during the temporary construction stage, the floor units are all positioned on one side of

the beam. This must be considered in the design of the beam at the end connections to the column. Usually, the types of beams selected do not depend on the function of the building. However, a flat or wide rectangular precast concrete beam is commonly used to support a long-span hollow core slab because it provides sufficient bearing seating for the slab. Meanwhile, inverted T-beams and edge beams are used for internal and external beams to increase the ceiling height, respectively. A secondary beam is used to transfer the building load to the primary beam connected to columns for a floor layout.

Industrialized Building System (IBS) – Precast Concrete Column

Precast concrete columns are the main vertical load-carrying members in precast structures. The structural design of precast concrete columns is no different from ordinary reinforced concrete columns, except for the loading history that a precast concrete column experiences during manufacturing, transportation, and erection. The main design differences at the ultimate limit state are the function of the precast concrete structure and connection types rather than the resulting analysis of the column section. Normally, precast concrete columns can be fabricated up to four stories high. However, for easy handling and transportation, one and two-story-high columns are preferred.

Timber Frame

Types of Timber Frame

There are several prefabrication systems in building a timber house which is listed as follows:

- *Pre-cut system*

The oldest fabrication system is where pieces of timber are processed, cut to the required lengths, notched, or drilled at the factory. The pieces are then marked and transported to the site for assembly. Transportation of the pre-cut timber is simple because it can be bundled into units and delivered to the building site. Compared to the conventional method

of cutting timber in failing lengths at site, this system is more accurate in its measurement, and material wastage is minimized.

- *Modular panel system*

In this system, building components are constructed in the factory by two or three labours without the use of any cranes and lifting devices. Wall panels are in uniform sizes using a module (M) as a unit of measurement. The normal unit is 4 ft in length, like the length size of most cladding materials in Malaysia such as plywood, hardboard, chipboard, and cement board.

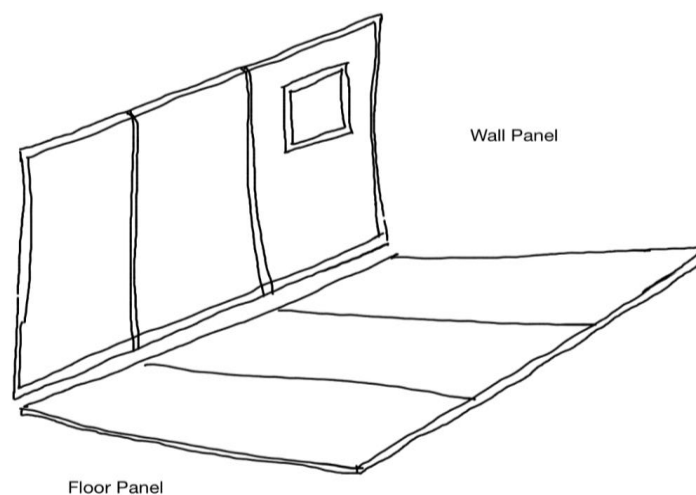


Figure 4.17 Example of a modular panel system*

- *Large size panel system*

This system is suitable for use when constructing many small houses at the same time. Large panels of 10m to 12m equivalent to the length of houses can be assembled in the factory and delivered to the building for erection. This system reduces the problem of joining together the small, prefabricated panels at the building site.

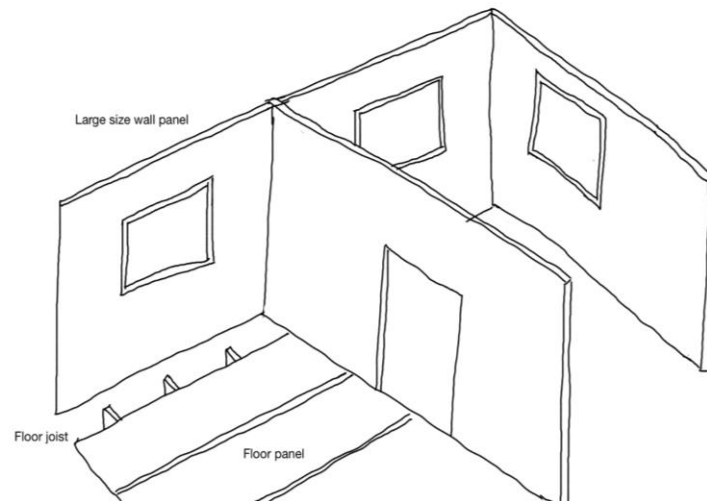


Figure 4.18 Example of large size panel*

- *Volume element system*

In the volume element system of prefabricated housing, it is finished at the factory. This system permits a home buyer to see exactly how the house looks like before it is built. This method is much faster than the other methods as far as site erection is concerned, but it requires the use of trailers for transportation, and cranes for lifting and erection.

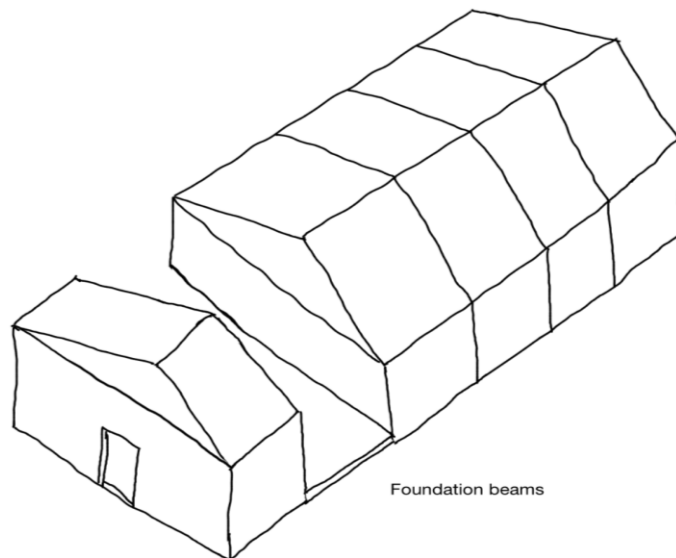


Figure 4.19 Example of volume element system*

Advantages of Timber Frame

There are many benefits of the timber-framed system in construction projects:

- i. Transportation of pre-assembled panels is simple
- ii. Less labour is required on-site, even when the panels are made up on site. If the panels are assembled at the factory, considerable savings in labour are possible
- iii. The pre-assembled wall panels can be erected manually by two or three men without the use of cranes
- iv. Speedier erection. It is possible to put up the whole timber-framed wall panels of the house within two to three days
- v. Flexibility in architectural design, modification, and extension is possible

Construction Method of Timber Frame

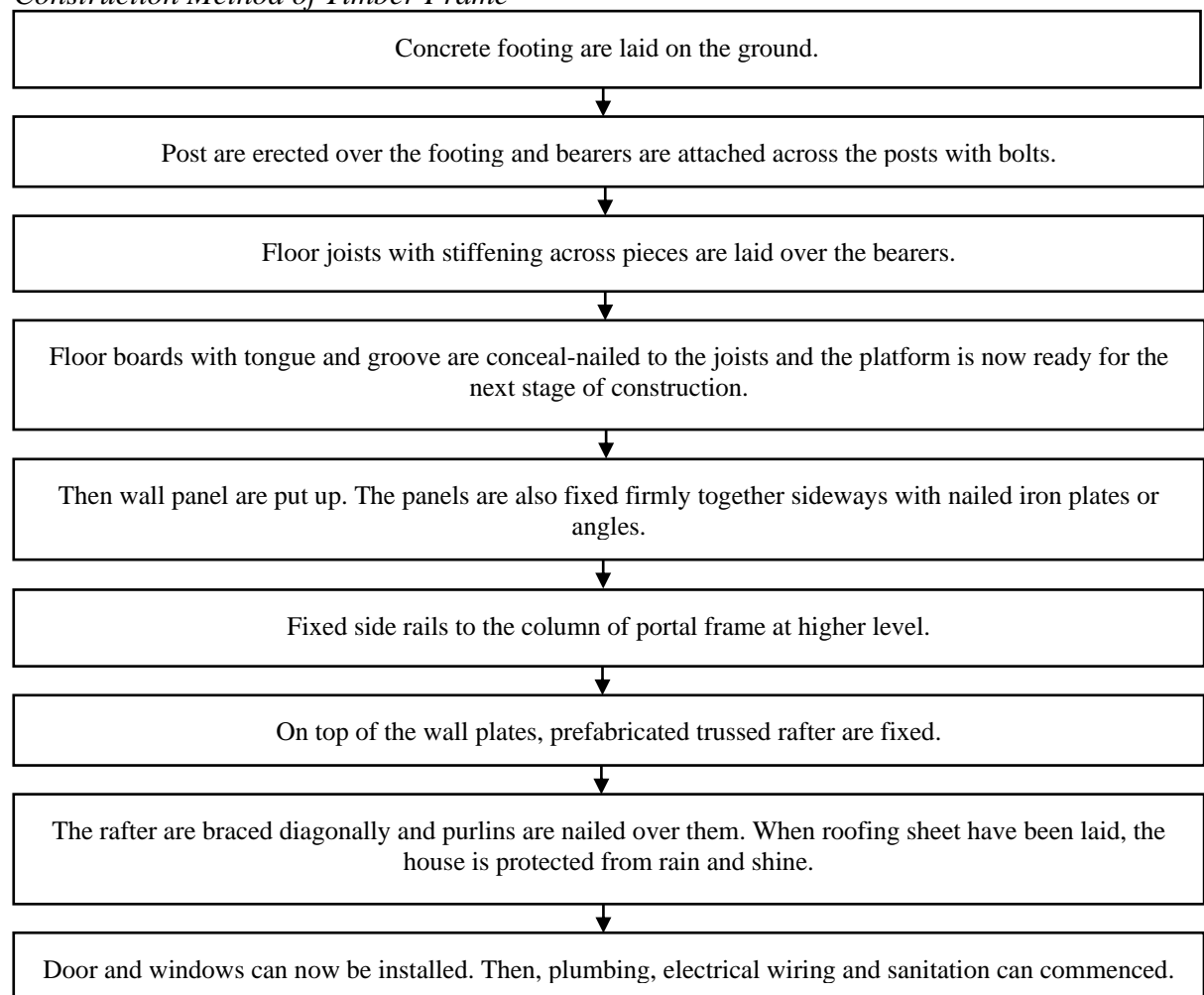


Figure 4.20 Timber Frame construction sequence

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ACKNOWLEDGEMENT/CONTRIBUTION SOURCES

*Ts. Siti Nur Aishah Mohd Noor

TOPIC 5

UPPER FLOOR

UPPER FLOORS SYSTEM

The upper floor is an integral part of the building structure that transfers the load to the artificial foundation. The choice of a flooring system depends on the following factors:

Design Factors

- i. Type of building (Residential, commercial, industrial, etc. Height: Low rise, medium rise and high rise)
- ii. Maximum clear span (in low rise building; from two external walls)
- iii. Type of support
- iv. Fire resistance

Buildability Factors

- i. Speed of construction
- ii. Ease of access to and within the site
- iii. Availability of working space
- iv. Need for temporary works (formwork and falsework)

FUNCTIONAL REQUIREMENTS OF UPPER FLOOR

The main functions of upper floors are:

- i. To provide a level surface.
- ii. To be capable of supporting the expected loads.

- iii. To provide adequate fire protection, sound insulation, thermal insulation, be durable, and allow for integration of services.
- iv. Other important considerations: speed, safety, and the environmental impact of construction.

General Functional Requirements for upper floor:

- i. Strength and stability.
- ii. Durability/freedom from maintenance.
- iii. Fire safety.
- iv. Resistance to passage of sound.
- v. Resistance to passage of heat – ground floor and roof.

PERFORMANCE REQUIREMENTS OF UPPER FLOOR SYSTEM

Strength and Stability

To provide strength and stability for dead, imposed, and wind loads (seismic loads). Under load, any horizontal member will deflect. For beams, floors and flat roof structures under service loads need to provide tensile strength in the lower portion of the structure – it governs the position of the reinforcement in simple R.C. slabs. Deflection must be limited to minimise cracking of surface finishes (e.g., ceilings and partitions to provide reassurance to building occupants). Floors can also be used to provide lateral stability.

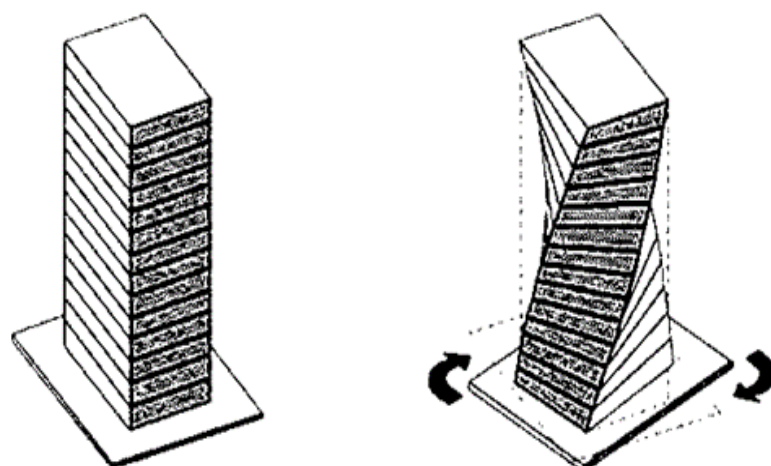


Figure 5.1 Rigid floors against horizontal racking

Allowable deflection under load is as follows:

- i. Range from 1.2m (4mm deflection) to 14m (46.7mm deflection).
- ii. Varies dependent on the application – $L/180$, $L/280$ etc.
- iii. To minimise cracking of rigid finishes, the allowable deflection ratio is $L/300$.

Table 5.1 Deflection limitations for upper floor

| Type of member | Deflection to be considered | Deflection Limitation |
|---|---|-----------------------|
| Flat roof not supporting or attached to non-structural elements likely to be damaged by large deflection | Immediate deflection due to live load | $L/180$ |
| Floors not supporting or attached to non-structural elements likely to be damaged by large deflection | Immediate deflection due to live load | $L/360$ |
| Roof or floor construction supporting or attached to non-structural elements likely to be damaged by large deflection | That part of the total load deflection of non-structural elements (sum of the long-time deflection due to all sustained loads and the immediate deflection due to any additional live load) | $L/480$ |
| Roof or floor construction supporting or attached to non-structural elements not likely to be damaged by large deflection | | $L/240$ |

Durability and freedom from maintenance

Need to avoid corrosion –the deterioration of materials by chemical interaction with their environment. Unlike some columns and beams, intermediate floor structures will not generally be exposed to the elements; roof structures should be protected by a waterproofing layer. The cover must be reinforced in reinforced concrete to protect against corrosion depending on the service environment – typically 15mm internal to the building, 50mm or more externally – this dimension may need to be increased to achieve requisite fire resistance.

Fire safety

- i. Floor structures may need to achieve a certain level of fire resistance e.g., FR60.
- ii. Finishes to floors and roofs may need to be non-combustible and/or to meet requirements relating to the surface spread of flame.
- iii. Floors may act as compartment floors.
- iv. Other performance requirements of upper floors, including resistance to the passage of sound while for roofs, are resistant to weather.

Table 5.2 Fire safety requirements for upper floors
(Reference: BS4422-2055 Fire Safety Vocabulary)

| Abbreviation | Description |
|--------------|---|
| FR 30/60 | Fire Resisting Construction (30/60 minutes) |
| FRG 30/60 | Fire Resisting Glazing (30/60 Minutes) |
| FD30 | Fire Door 30/60 Minutes |
| FD60 | Fire Door 60/60 Minutes |

UPPER FLOORS MATERIALS

There are mainly three types of materials that can be used for the construction of the upper floor in Figure 5.2:

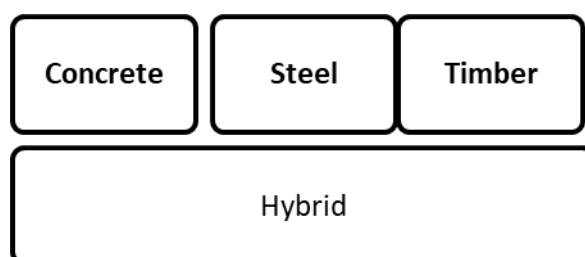


Figure 5.2 Upper floor construction materials

Concrete floors

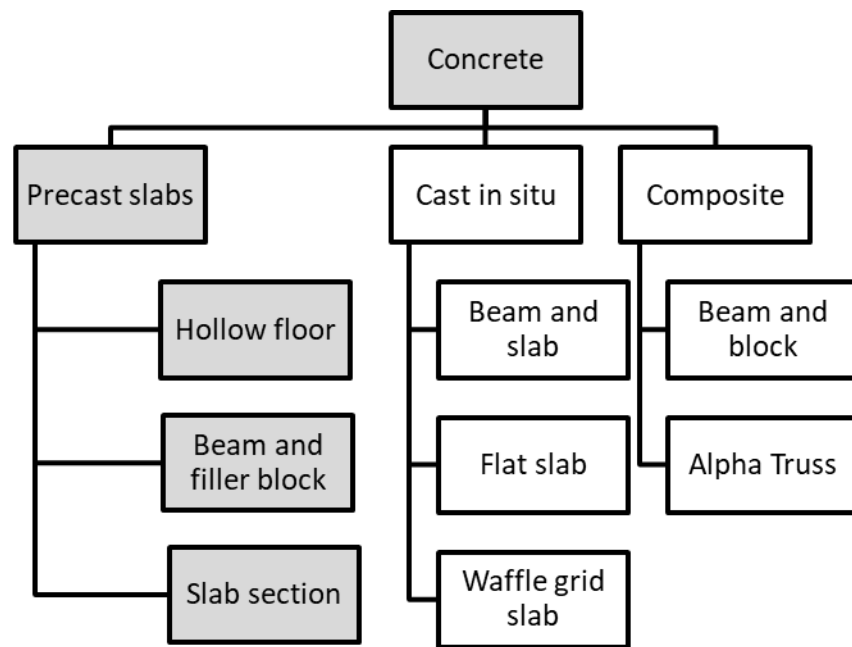


Figure 5.3 Types of concrete floor: Precast

Precast Slabs

General description of precast slab floor:

- i. Precast floor panels are generally factory cast and lifted into position on-site. Supported by beams and walls, they are quick and easy to install. A concrete topping may be required for further reinforcement and to ensure a level finish.
- ii. Popular in multi-storey buildings:
- iii. High construction speed.
- iv. No need for formwork.
- v. Mostly precast slabs or beams.
- vi. Dense or aerated concrete.
- vii. It can be pre-stressed.
- viii. It can be hollow.

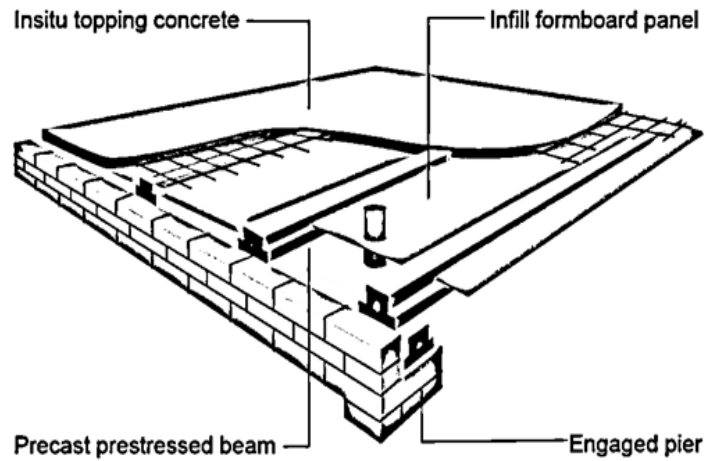


Figure 5.4 Elements of precast concrete floor

Precast Plank Floors


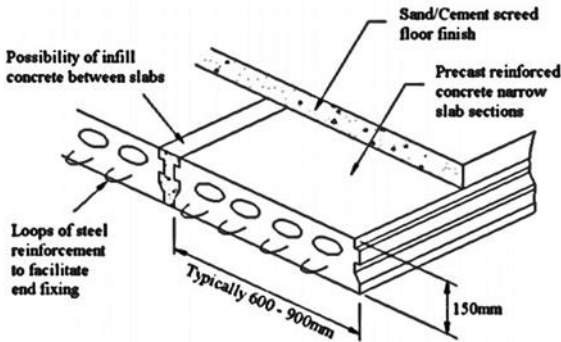
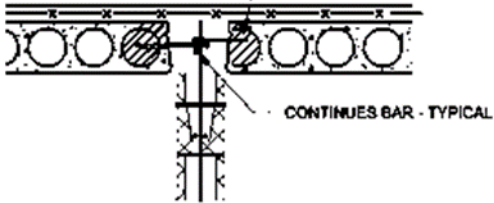
- i. Mostly used for upper floors of low-rise purpose-built flats
- ii. Higher levels of fire protection
- iii. Higher levels of sound insulation
- iv. Greater spans than timber
- v. Precast, pre-stressed concrete slabs



Figure 5.5 Plank floor

The floor is finished with a 40mm thick layer of concrete topping to tighten up the floor and fill up any gaps, thus improving fire protection and sound insulation.

Table 5.3 Types of precast slabs

| Illustrations | Description |
|---|--|
| <p>Hollow floor:</p>   <p>HOLLOW PRE-CAST FLOORS (NARROW SLAB)</p> <p>AT JOINTS SHOWN IN PLAN (MAX. SPACING AT 1220 O.C.) PROVIDE 125X125X100 dp. BLOCKOUTS C/W 2 BARS AT EACH BLOCKOUT. EXTEND 2 BAR TO CENTERLINE OF CORE AND TO CENTERLINE OF CMU WALL. GROUT SOLID WHEN IN INSTALLED - BY OTHERS</p>  | <p>It is also known as a voided slab, hollow core plank, or simply a concrete plank is a precast slab of prestressed concrete.</p> <p>Height adjustable pedestals.</p> <p>It has a jointless surface.</p> <p>Best fire rating.</p> <p>Quick installation.</p> <p>Wide choice of coverings.</p> <p>Types of hollow slab:</p> <ol style="list-style-type: none"> 1. Regular floor slab panels 2. Special panels for the accommodation of services 3. Insulated panels 4. Climate floor for energy storage |

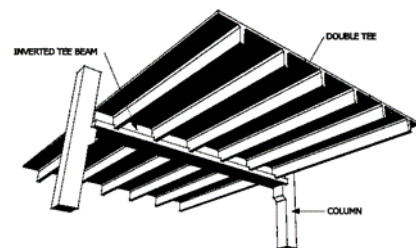
Slab Section:



The precast system doesn't require the extensive formwork of a cast-in-place concrete slab and is more flexible for projects that need to be phased, such as improving buildings in informal settlements.



Precast "double TEE"



Beam and filler blocks:



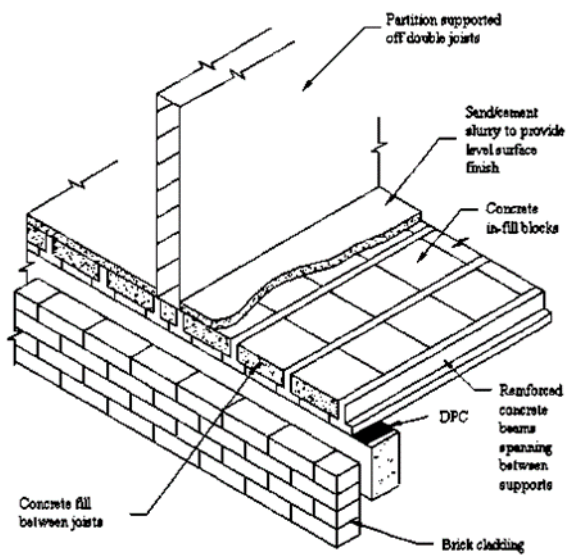
Inverted tee beams, placed alternatively with precast infill blocks.

It can be used with in-situ concrete frames, precast concrete frames or structural steel.

Tee beams and infill blocks are manufactured off site (factory).

It requires a concrete topping.

With blocks or pots with voids to reduce self-weight. A slab is then finished with a screed.



BEAM AND BLOCK FLOORS



Key advantages:

Easy to introduce holes e.g. services.

Voids reduce self-weight.

Uses small repetitive components.

Immediate safe platform

Used in houses:

Solid "T" beams with hollow (or solid) concrete infilling blocks.

Depth varies between 130- 250mm.

Width is normally 40mm at the top and 90mm at the bottom.

Cast In-Situ Concrete Floor

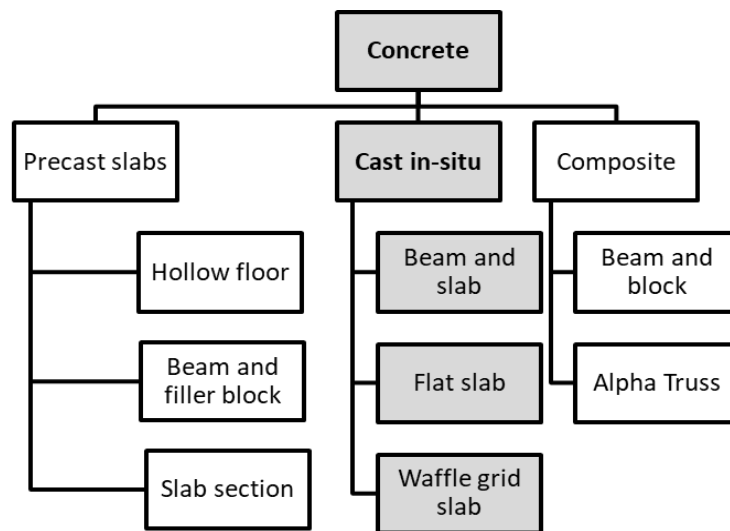


Figure 5.6 Types of concrete floor: Cast in-situ

They are poured on-site into temporary or permanent formwork, supported by walls or beams. They allow for great design flexibility. The internal walls can be positioned anywhere on the floor, irrespective of the room layout below.

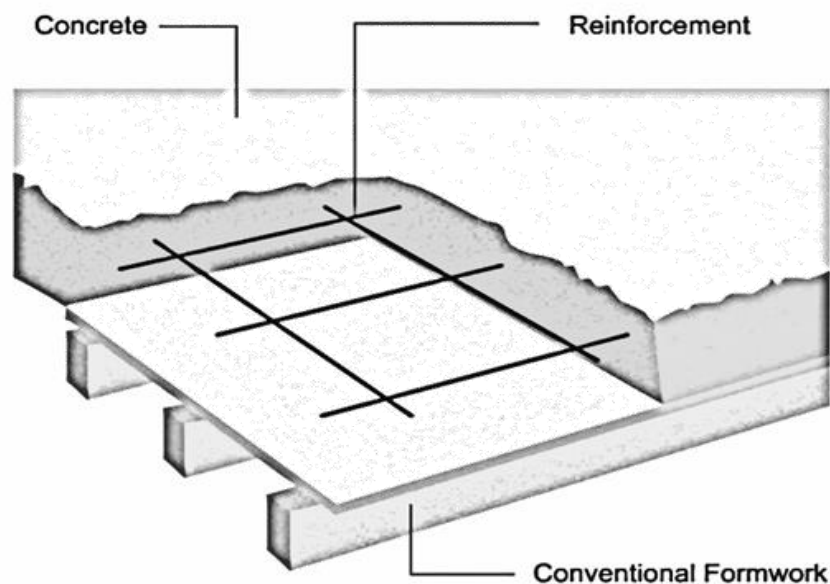


Figure 5.7 Elements of in-situ concrete floor

Used with framed buildings (columns and beams). Requires temporary support: Formwork is made of plywood boards and falsework consists of a series of props.



Figure 5.8 Formwork and falsework for in-situ concrete floor

Reinforcement is required where tensile stresses are greatest at midspan (bottom) and support (top).



Figure 5.9 Reinforcement (including services) for the in-situ concrete slab


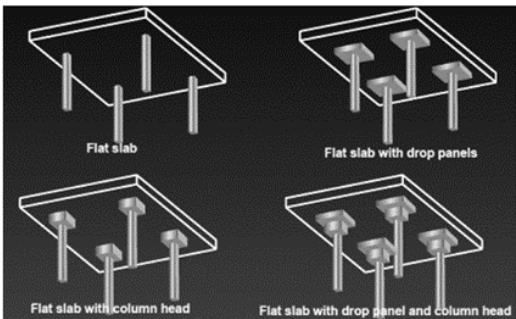
Wet concrete is hoisted to the formwork. The typical slab thickness is between 100-300mm.

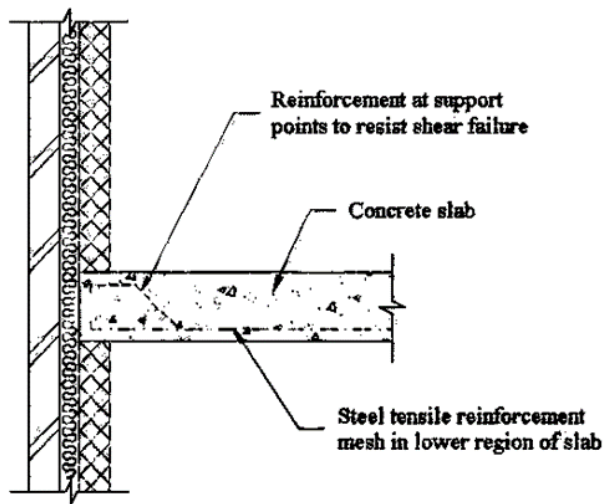


Figure 5.10 Pouring of the wet concrete

Floor slab poured together with beams (integrated system). May be solid or contain hollow pots. May be a waffle construction. Mostly used for buildings up to 4 storeys. Highly flexible. Thickness can be increased. However, they are heavy types of floors.

Table 5.4 Types of floors: cast in-situ concrete

| Illustrations | Description |
|--|---|
| <p>Flat Slab:</p>  |  <ul style="list-style-type: none"> Drop panels act as T-beams over the supports, increasing the shear capacity and the stiffness of the floor system under vertical loads, so increasing the economical span range. |



SIMPLE REINFORCED CONCRETE FLOORS



flat slab with drop panel and column head

Advantages:

- Simple formwork is used.
- No beams-simplifying under-floor services outside the drops.
- Minimum structural depth.
- Usually does not require shear reinforcement at the columns.

Disadvantages:

- It has medium spans.
- It is not suitable for supporting brittle (masonry) partitions.
- Drop panels may interfere with larger mechanical ducting.
- Vertical penetrations need to avoid the area around columns.
- For reinforced flat slabs, deflection at the middle strip may be critical.

Waffle/grid slab



- A waffle slab is flat on top, while joists create a grid-like surface on the bottom. The grid is formed by the removal of moulds after the concrete sets.
- Use on longer spans and with heavier loads.
- Use for buildings that require minimal vibration e.g., laboratories and manufacturing facilities
- made in different ways but generic forms are needed to give the waffle shape to the slab.
- The formwork is made up of many elements: *waffle pods, horizontal supports, vertical supports, cube junctions, hole plates, clips and steel bars.*



- First the supports are built, then the pods are arranged in place, and finally the concrete is poured.

The process:

- **In situ:** Formwork construction and pouring of concrete occur on-site, then the slab is assembled.
- **Precast:** The slabs are made somewhere else and then brought to the site and assembled.
- **Prefabricated:** The reinforcements are integrated into the slab while being manufactured, without needing to reinforce the assembly on-site. This is the most expensive option.

Composite Concrete Floor

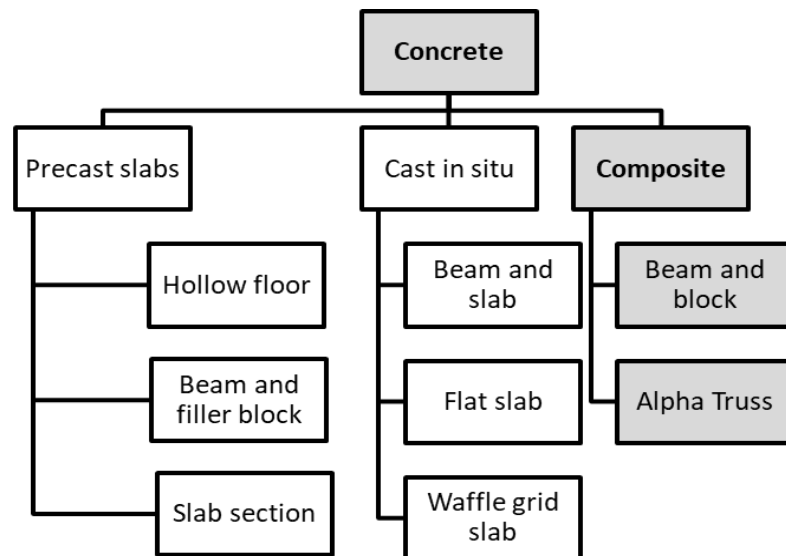


Figure 5.11 Pouring of the wet concrete: Composite.

Are an increasingly common in situ option. The concrete is poured onto proprietary steel decking, supported by walls or beams, which acts as formwork and partial reinforcement for the floor slab.

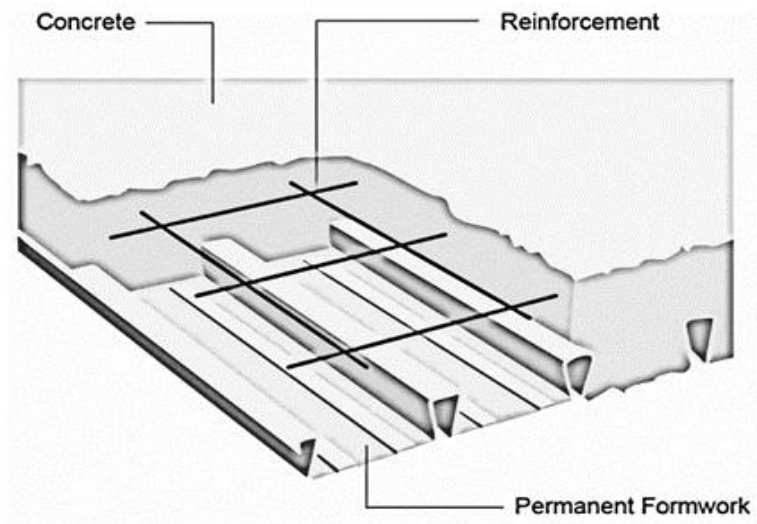


Figure 5.12 Elements of composite floor



Figure: 5.13 Pouring of concrete on the steel deck

Alpha Truss



Figure: 5.14 Composite floor- Alpha truss

Beam and Block

It is used for ground floors and multi-storey buildings. The upper floor is made of cast concrete and prestressed concrete beam, which can be an inverted T-shaped beam or lintel; the other piece is a simple rectangular block. The blocks are placed at regular intervals and the beams placed between them are made of hollow concrete filler blocks.

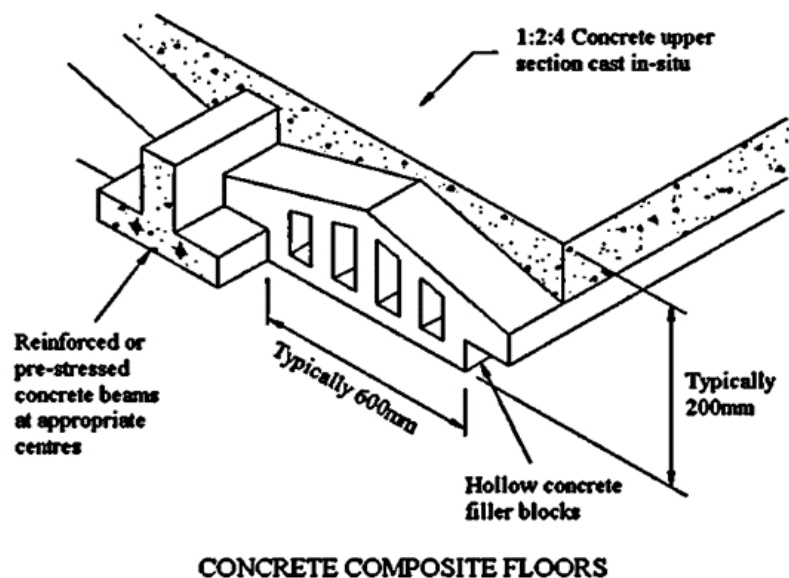
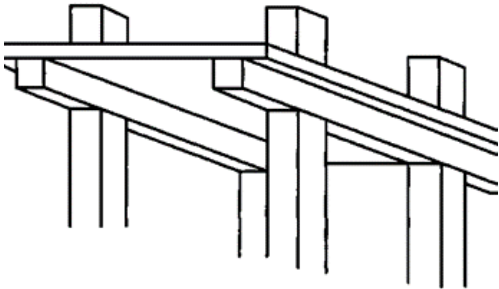
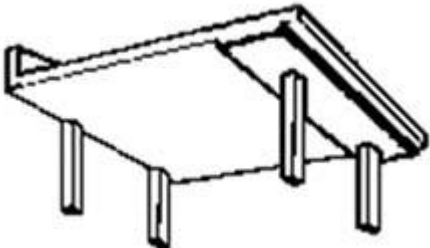


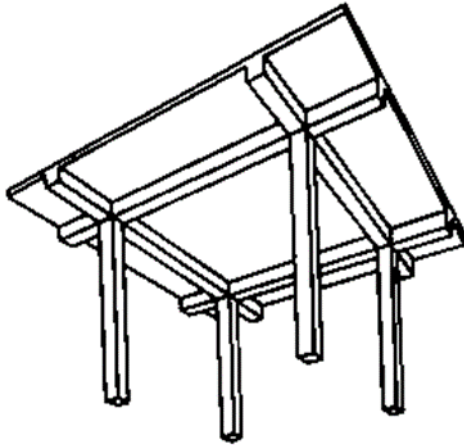
Figure: 5.15 Composite floor: Beam and blocks

SUMMARY OF TYPES OF FLOOR SLABS

Table 5.5 Types of floor slabs

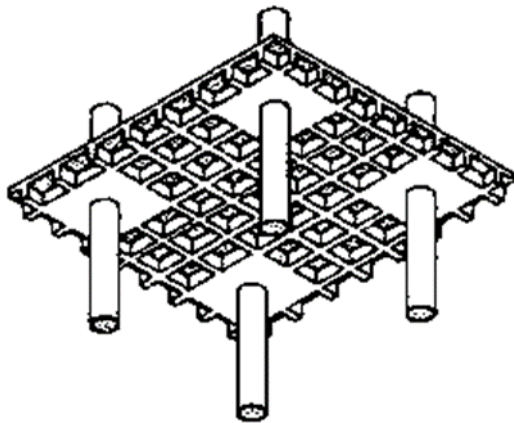
| Illustrations | Description |
|---|--|
| <p data-bbox="260 394 579 421">One way flat slab with beams</p>  | <ul style="list-style-type: none"> • A one-way reinforced concrete floor or roof system consists of members that have the main flexural reinforcement running in one direction. • Beams support larger span. • Slab and beams act monolithically – like a T or an L. • Simple, quick, economical. • The limited surface area makes it hard to exploit thermal mass. • Down stand beams can cause problems with services and shadows. • Readily pre-stressed for long spans. • A flexible plan for partitions and services. |
| <p data-bbox="260 976 639 1003">One way flat slab with band beams</p>  | <ul style="list-style-type: none"> • It is used for light loads • Fast, simple construction (reusable formwork) • Thin slabs • Good daylighting, depending on orientation (small down stand also helps with the insertion of services) |

Two-way slab with beams



- Two-way floor and roof systems transfer the supported loads in two directions.
- Flexural reinforcement must be provided in both directions.
- Suitable for higher loadings e.g., warehouses where there is relatively little servicing (down stands can interfere with service runs)
- Suited to a regular grid
- Readily pre-stressed for long spans

Waffle slab



- High surface area (FES)
- Relatively easy to introduce holes for services.
- Distinctive profiled soffit – architectural possibilities
- Voids reduce self-weight

REINFORCEMENT COMPONENTS FOR UPPER FLOOR: CAST IN-SITU CONCRETE

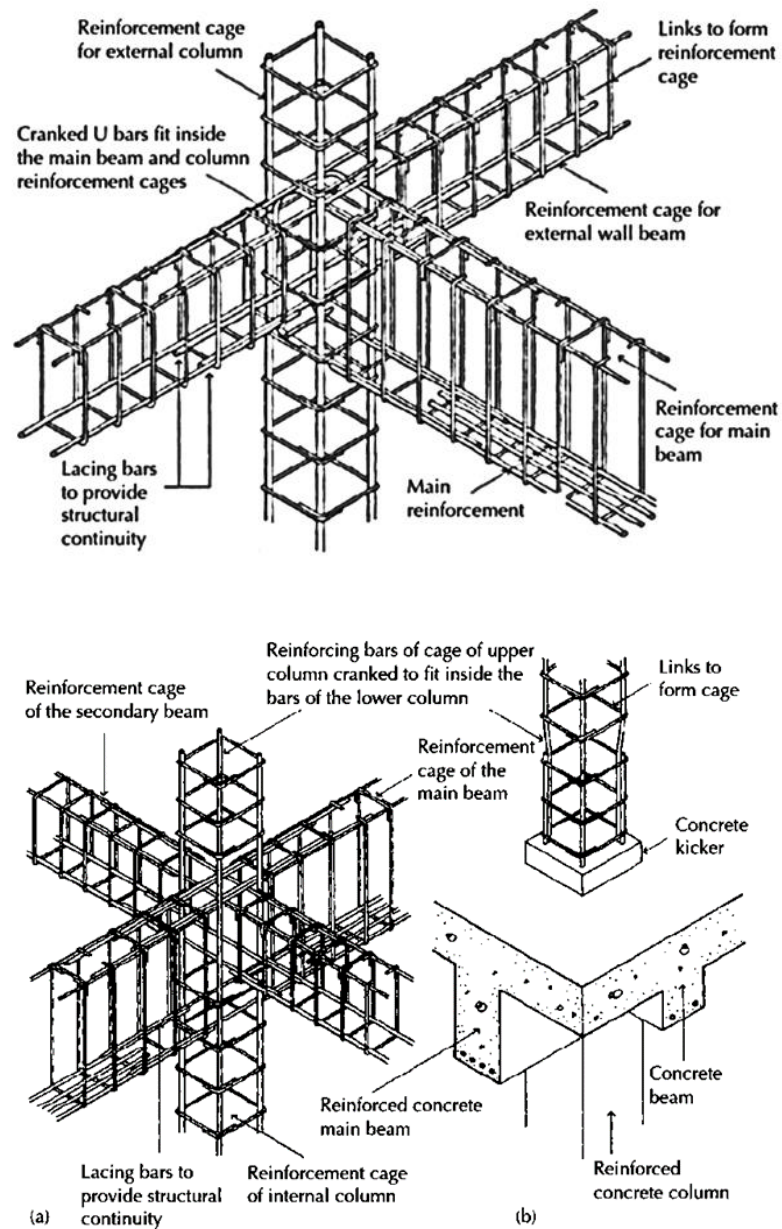


Figure: 5.16 Steel reinforcement for columns and floor beams

FORMWORK COMPONENTS FOR UPPER FLOOR: CAST IN-SITU CONCRETE

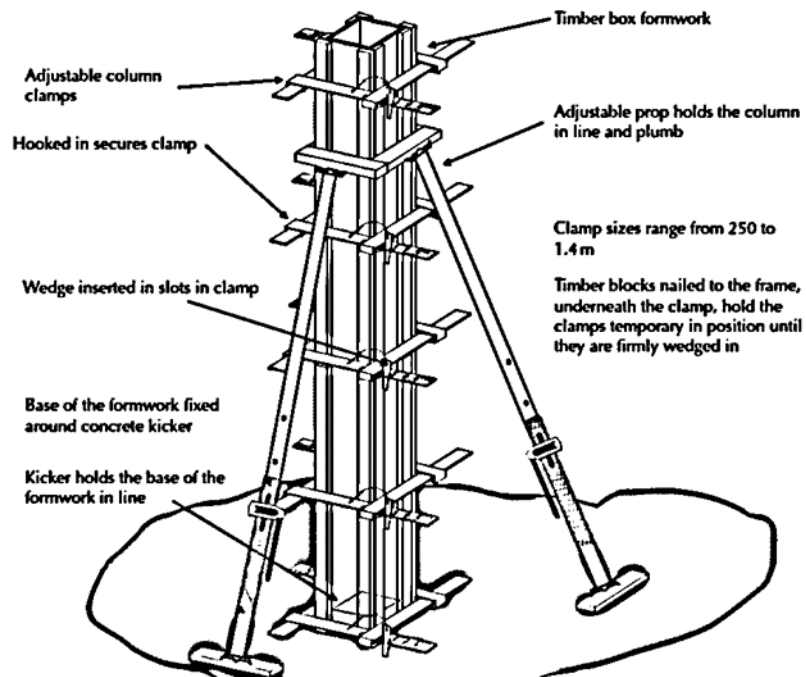


Figure: 5.17 Formwork for columns

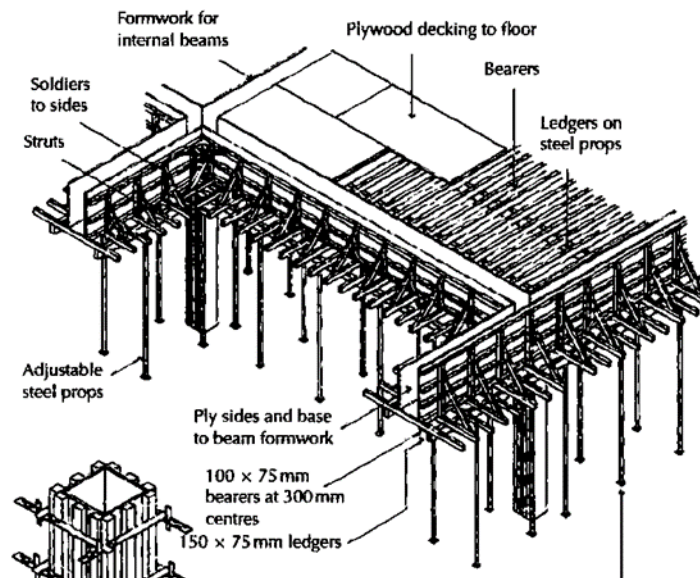








Figure: 5.18 Formwork and falsework for upper floor slab

THE PROCESS OF UPPER CONSTRUCTION- REINFORCED IN-SITU CONCRETE FLOORS

Table 5.6 Construction sequence of floor slab

| Construction Sequence | Illustrations (photos of real project in Malaysia) |
|---|--|
| For ground floor <ul style="list-style-type: none"> The site clearance process is initiated after the site possession and after getting the necessary permission for cutting of trees from the Local Authority. Removal and disposal of unwanted material such as vegetation, dead stumps, etc. Piling must be precisely done according to the required depth level and dimensions. |  |
| <ul style="list-style-type: none"> For one-way spanning slabs, the bottom reinforcements are the main bars while the top bars are distribution bars, laid across the main bars. For two-way spanning slabs, the top & the bottom bars are the main bars. The bars are laid over and across the beam reinforcement bars. |  |
| Services for the ground floor <ul style="list-style-type: none"> Installation of sewer pipes, electrical and water pipes etc. along with the reinforcement bars is completed before pouring the concrete. Regular checking is required for the services to determine any loose/air-tight joints. |  |




| | |
|---|--|
| <ul style="list-style-type: none"> • Concrete is poured into the beam formwork first and overflow onto the slab formwork, normally 150mm thick. • Compactions using poker vibrators are carried out to remove air bubbles in the concrete |  |
| <ul style="list-style-type: none"> • Removal of formwork for the ground floor. • Erecting reinforcement for columns |  |
| <p>For upper floor</p> <ul style="list-style-type: none"> • Erecting formwork for columns. • Include timber box formwork with specific column's dimensions, adjustable columns clamps, props, wedges. |  |



For upper floor

- Concrete is pumped in the column formwork first and overflow onto the slab formwork, normally 150mm thick.
- Forming formwork for the upper floor.
- Formwork for beams and slab including plywood decking, struts, props etc.



| | |
|--|--|
| |  |
| <p>For upper floor</p> <ul style="list-style-type: none"> • The steel bars are laid over and across the beam reinforcement bars. • Installation of services for the upper floor. • Concrete is poured into the beam formwork first and overflow onto the slab formwork, normally 150mm thick. • Compactions using poker vibrators are carried out to remove air bubbles in the concrete |  |
| <ul style="list-style-type: none"> • Removal of formwork from the upper floor slab. |  |

| | |
|--|---|
| <ul style="list-style-type: none">● The steel bars are laid over and across the beam reinforcement bars.● Installation of services for the upper floor.● Concrete is poured into the beam formwork first and overflow onto the slab formwork, normally 150mm thick.● Compactions using poker vibrators are carried out to remove air bubbles in the concrete. |  |
| <ul style="list-style-type: none">● Installing formwork for the roof beam. |  |

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* Dr. Mustafa Klufallah

TOPIC 6

STAIRS

INTRODUCTION

Stairs are used to connect from one level to another level in a building. Stairs can be constructed from either concrete, steel or timber, or a combination of them. In Malaysia, stairs are commonly constructed from concrete.

TERMINOLOGY FOR STAIRS

Specific terminologies were used for stairs to ease the preparation of construction documents and the construction process. Following are the common terminologies used (Fleming, 2009; Foster, 2013):

- **Flight** - series of steps between landing or floors.
- **Landing** - the intermediate platform between two flights of a stair.
- **Riser** - the vertical element of the step.
- **Tread** - the horizontal element of a step.
- **Step** - a combination of tread and riser.
- **Pitch** - the angle of inclination of the stair with the floor.
- **Rise** - the vertical distance between two consecutive treads.
- **Going** - the horizontal distance between the nosings or risers of the two consecutive steps.
- **Nosing** - the projecting part of the tread beyond the face of the riser.
- **Pitch/ Slope** - the angle between the line of nosings and the line of the floor or landing.

- **Handrail** - supported by baluster that serves as a guard-rail to prevent user from fall during ascent and descent.
- **Baluster** - the vertical member which is fixed between string and handrail to give support to the handrail.
- **Balustrade** - the combination of handrail and balusters, to provide protection on the open side of a stair.
- **Headroom** - The vertical distance between the line of nosing and any obstruction over the stair, usually the soffit of an upper flight or the lower edge of a floor or landing.
- **Newel post** - the vertical member at the ends of a flight to connect the ends of strings and handrail.
- **Soffit** - the under surface of a stair. It is generally covered with ceiling of finished with plaster.
- **Waist** - the thickness of structural slab in case of an R.C.stair.
- **Walking line** - the average position taken up by a person ascending to descending the stair generally taken to be 457mm from the center of the handrail.

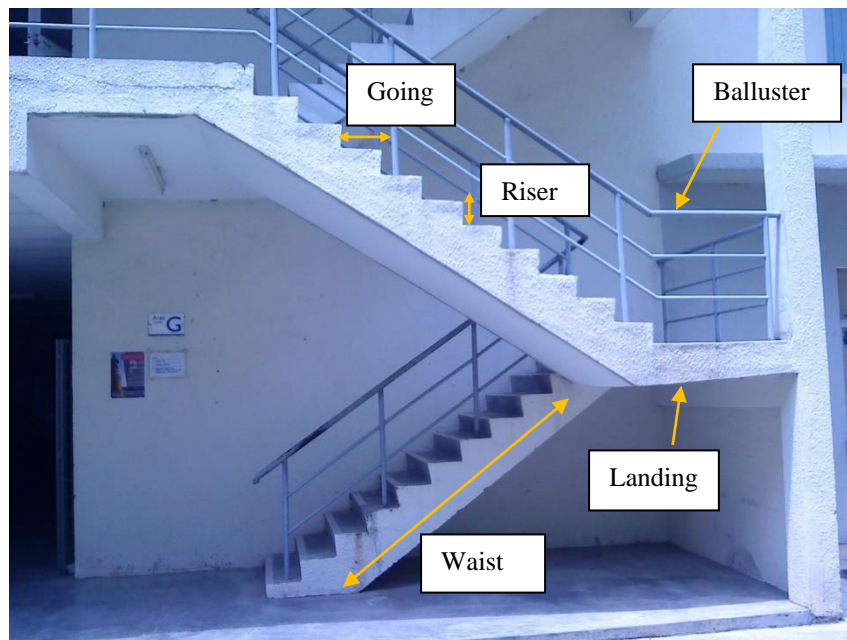
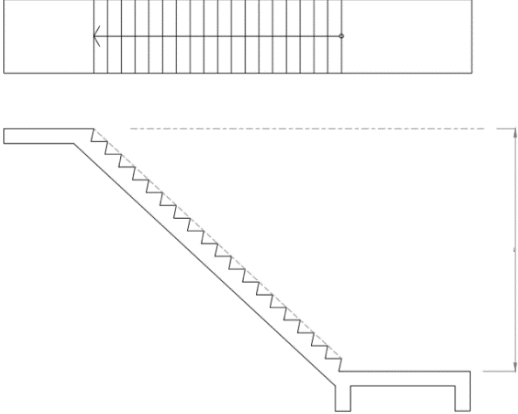
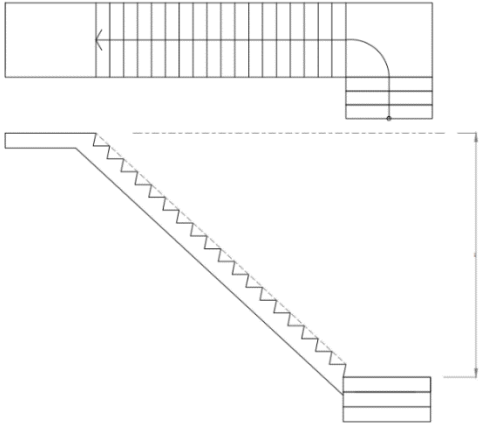
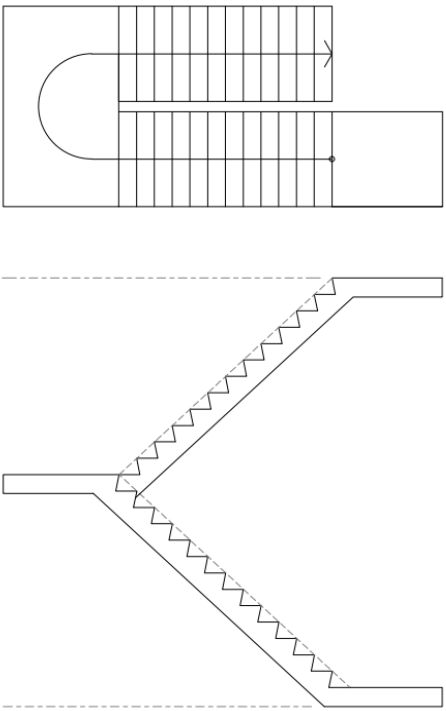
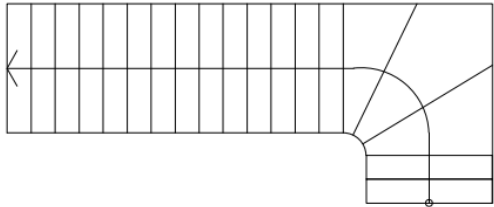
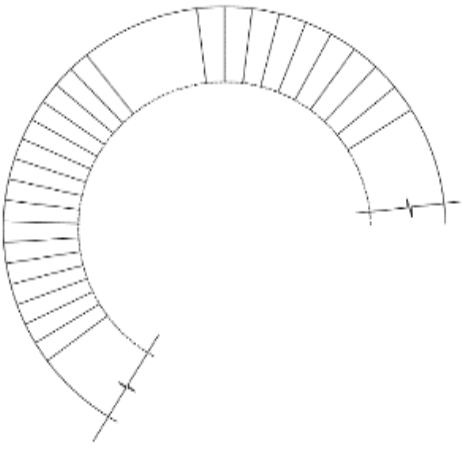


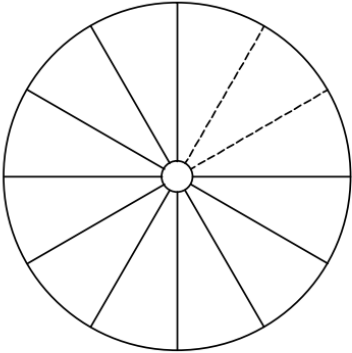
Figure 6.1 Terminology of stair*

TYPES OF STAIR

Table 6.1 Types of stairs

| Types of Stairs | Descriptions | Illustrations* |
|------------------------------|---|---|
| Single Straight Flight Stair | Simple construction which needs big space on plan. There is no landing in between the steps. The flight behaves like a supported slab spanning from one landing to another. |  <p>The diagram for a single straight flight stair consists of two parts. The top part is a plan view showing a rectangular area with a series of vertical lines representing the steps, spanning the entire width. The bottom part is a side elevation view showing a single, continuous flight of stairs between two horizontal levels, with a dashed line indicating the horizontal span.</p> |
| Quarter Turn Stair | Two flights with a quarter turn of 90° in between the flights, forming an L-shape on plan view. The landing in between the flights can be the resting place. There is no limitation of steps for both flights. Need more space on a floor plan. |  <p>The diagram for a quarter turn stair also consists of two parts. The top part is a plan view showing two flights of stairs meeting at a 90-degree angle, forming an L-shape. A small rectangular area at the corner represents the landing. The bottom part is a side elevation view showing the two flights of stairs between two horizontal levels, with a dashed line indicating the horizontal span.</p> |

| | | |
|------------------------|---|---|
| <p>Half Turn Stair</p> | <p>Two flights with a 180° in between, connected by a landing slab. The flight could be expanded to have a bigger distance between the two flights. The length of flight can be equal or unequal in length. Commonly used to save space, especially for high-rise buildings that need many series of flights.</p> |  <p>The diagram illustrates a half-turn stair. The top part is a plan view showing two rectangular flight slabs connected by a central landing slab. The first flight goes up, and the second flight goes down, forming a 180-degree turn. The bottom part is a side elevation view showing the two flights meeting at a central landing platform, with dashed lines indicating the floor and ceiling levels.</p> |
| <p>Winding Stair</p> | <p>The flights are connected by winders (please refer to figure), not allow to be used as fire staircase due to the potential hazard by winders.</p> |  <p>The diagram shows a plan view of a winding stair. It consists of two rectangular flight slabs connected by a quarter-circle winder. Arrows indicate the direction of travel: up the first flight, across the winder, and down the second flight.</p> |
| <p>Circular Stair</p> | <p>With a circular plan configuration, usage is limited by building regulations.</p> |  <p>The diagram shows a plan view of a circular stair. It is a semi-circular arrangement of steps, with a dashed line indicating the center of the circle. Arrows at the ends indicate the direction of travel.</p> |

| | | |
|--------------|--|--|
| Spiral Stair | With a series of treads from wedge shape around a central column. Use to save space, normally only allowed for residential dwelling units. |  |
|--------------|--|--|

CONSTRUCTION SEQUENCE OF REINFORCED CONCRETE STAIRCASE

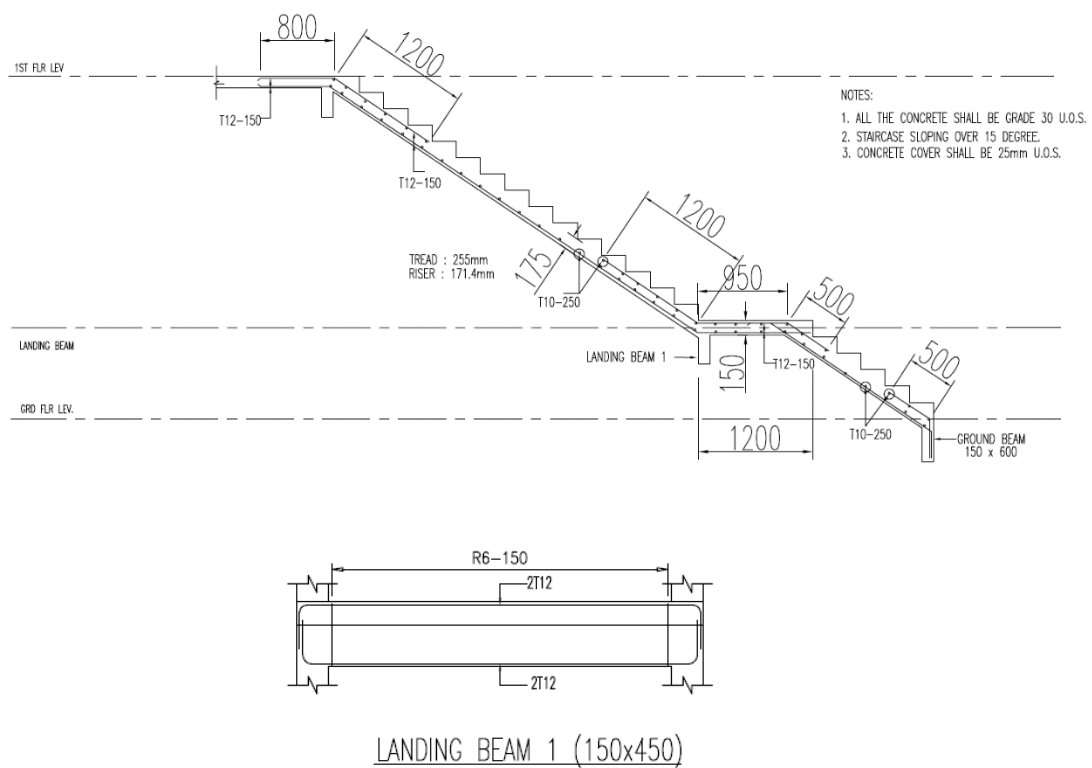





Figure 6.2 Reinforcement detail for stairs*

Typical reinforcement details for stair flights and landing beam, the reinforcement of stairs (both flight and landing slab) are similar to reinforcement for the slab. The reinforcement is concentrated at the bottom of the concrete structure.

Same as all the casting work for concrete slab, a soffit formwork is formed using plywood. A wall board is used as side formwork before the workers start to lay the reinforcement.

Table 6.2 Construction sequence of stairs

| Construction Sequence & Descriptions | Illustrations* |
|---|--|
| The supports to soffit formwork erected |  |
| Soffit formwork erected |  |

| | |
|-------------------------|---|
| |  |
| Soffit formwork erected |   |



Side Board (side formwork)

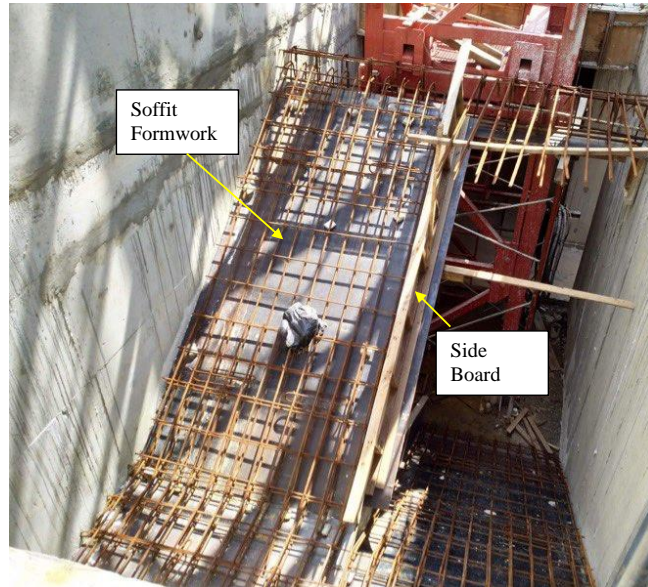


Side Board (side formwork)

Preparation of reinforcement





An overview of the side formwork, soffit formwork, and reinforcement

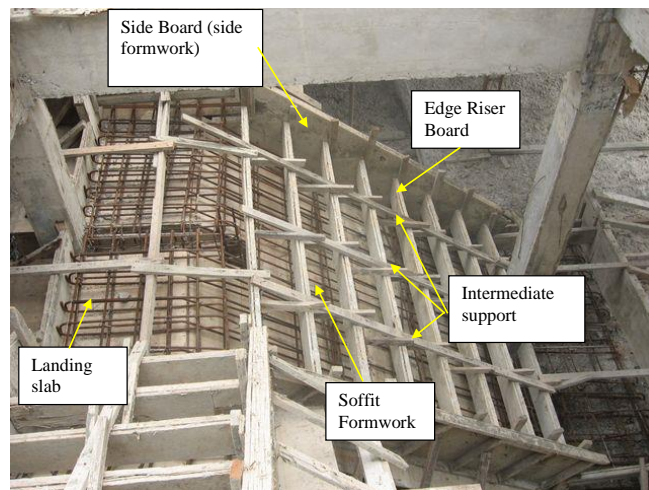
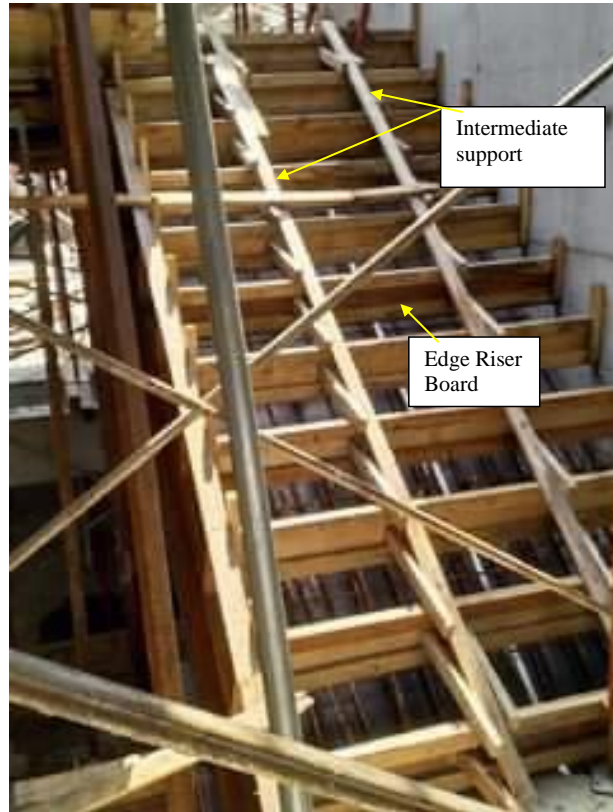


Any services or pipes to be hidden inside the concrete will be prepared before concrete is poured.



| | |
|---|---|
| |  |
| <p>The formwork for the riser is placed after the reinforcement is laid</p> |  |

After the bottom reinforcements are laid, the edge riser board will be erected with the intermediate support to enable the casting of steps.



Concrete pouring process requires the worker to spread the concrete into each step. Compaction is done.









Stair after formwork removal



RESOURCES

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ACKNOWLEDGEMENT/CONTRIBUTION SOURCES

* Dr. Lew Yoke Lian

TOPIC 7

ROOF

INTRODUCTION

A roof is a structure forming the upper covering of a building. Its primary purpose is generally to protect from the environment, but it may also contribute to safety, security, privacy, and insulation.

FUNCTIONAL REQUIREMENTS OF ROOFS

For the roof to function properly, certain requirements have to be fulfilled:

- i. Strong to receive and transfer loads.
- ii. Stable – no movement in receiving and transferring loading.
- iii. Waterproof – since it is exposed to the weather (sunlight, rain, snow).
- iv. Durable and low maintenance – due to the weather exposure.
- v. Fire-resistant - depends on the material.
- vi. Thermal insulated – it absorbs heat from the sunlight.
- vii. Sound insulated – against airborne sound, especially for buildings close to an airport or rail network.

TYPES OF ROOF STRUCTURE

Roofs can be categorised as pitched or flat. For the construction of pitched roofs, the lightweight metal roof structure is commonly used as compared to timber nowadays. However, this chapter will focus on the timber roof structure. As for flat roofs, reinforced concrete is commonly used.

PITCHED ROOF

Pitched roofs refer to any roof which slope is between 10 to 70 degrees to the horizontal lines. Below this range is called flat roofs, while above 70 degrees, it would be categorised as a wall. Typical pitched roofs are constructed as symmetrical pitch roofs with equal slopes pitched to a central ridge as illustrated in Figure 7.1. The slope for pitched roofs is determined by the ability of the roof covering to drain the rainwater immediately. This is an important factor, especially in tropical countries.

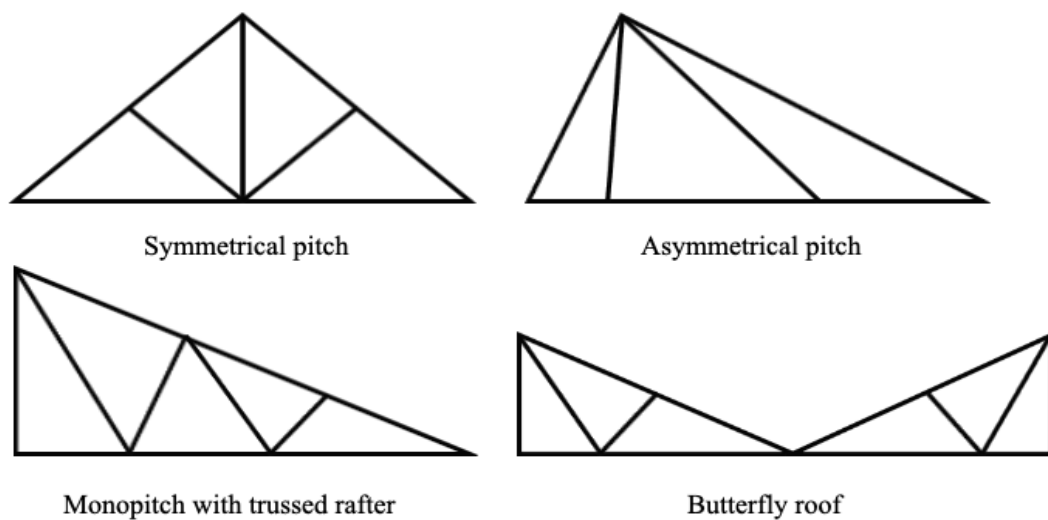


Figure 7.1 Types of pitched roof*

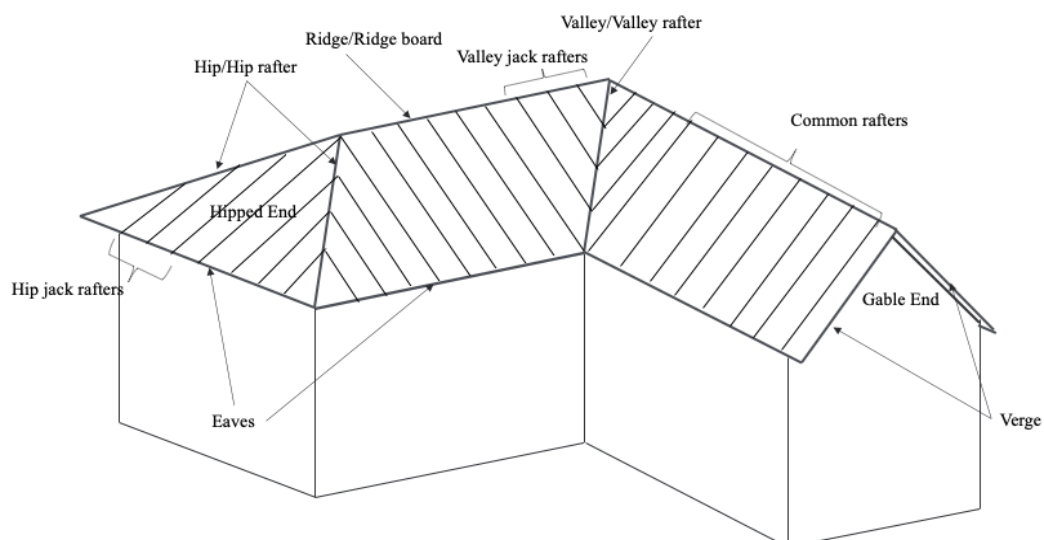


Figure 7.2 Pitched roof terminology*

Timber Structure

It is common practice to construct pitched roofs from prefabricated timber trusses as compared to the traditional timber roof built on site. However, as an aid to the understanding of construction and terminology, this section will describe the construction of a traditional timber roof built on site.

Figures 7.3 to 7.6 show the details and components of the timber pitched roof members as listed below:

- i. Wall plate
- ii. Rafters (common rafter, hip, and valley rafter)
- iii. Struts
- iv. Ceiling joist or tie beam
- v. Ridge board

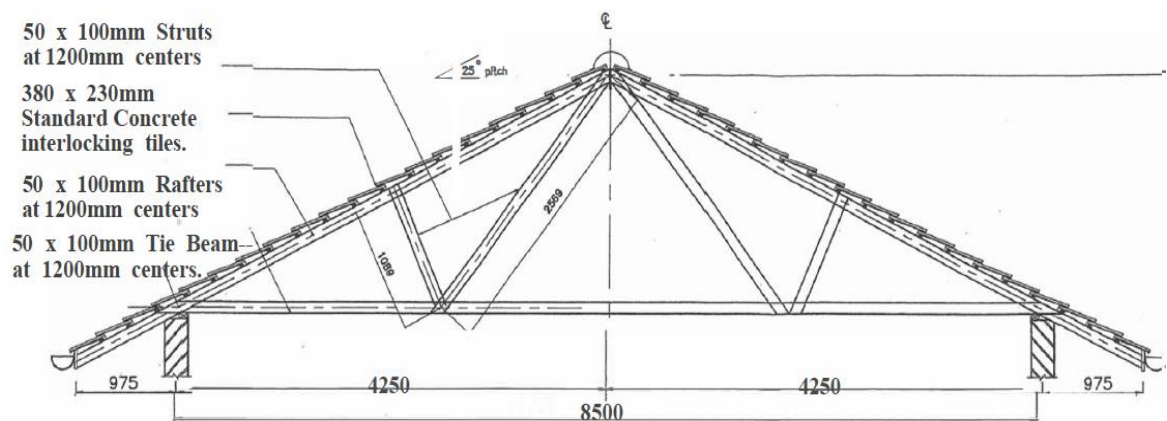


Figure 7.3 Timber pitched roof details*

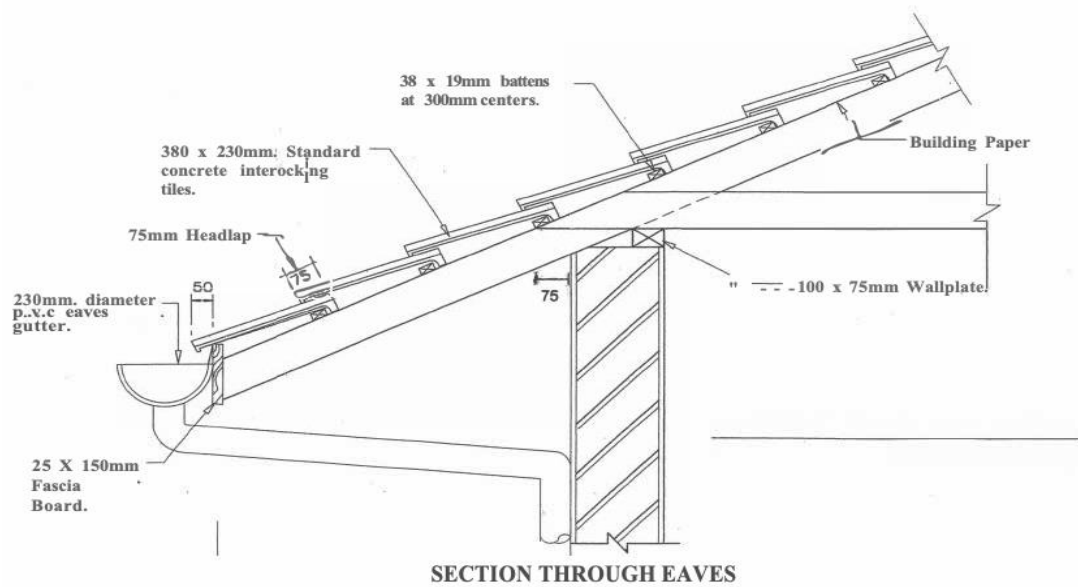


Figure 7.4 Timber pitched roof details through eaves*

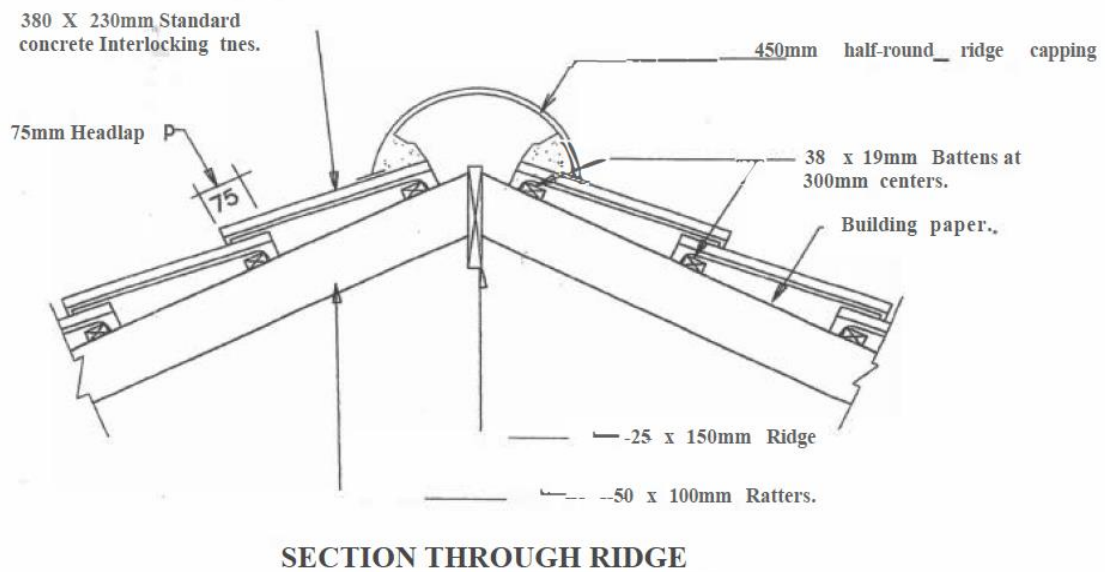


Figure 7.5 Timber pitched roof details through ridge*

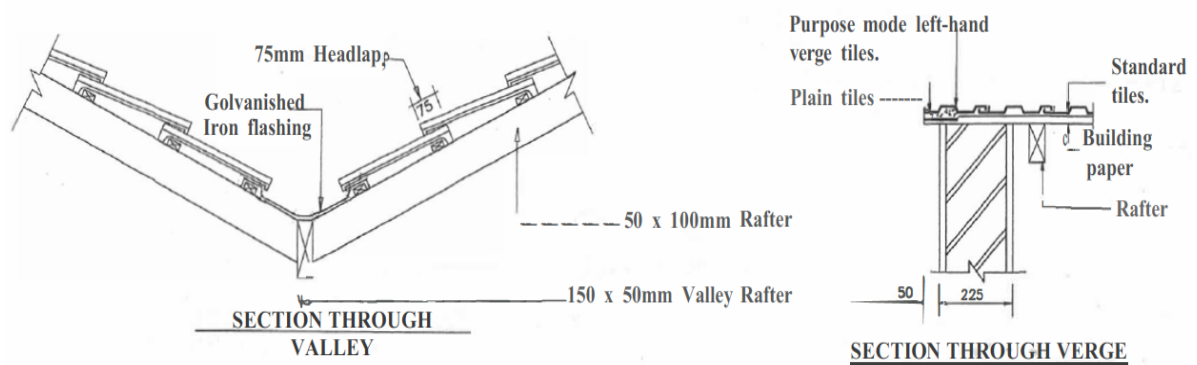


Figure 7.6 Timber pitched roof details through valley and verge*

FLAT ROOF

A flat roof is a roof that is completely or almost level. However, whilst the roof is described as ‘flat’ almost all flat roofs are laid to a fall to ensure that rainwater can run off to the lower side. The Scottish Technical Handbook - Domestic, describes flat roofs as having, “...the slope of which does not exceed 10° from the horizontal”.

Reinforced concrete flat roofs are very common in countries with hot and dry climates (eg. Middle East countries). They were seen as a cheaper alternative to traditional pitched roofs. However, longevity for some flat roofs is poor, ranging from 6 years to 35 years, depending on the quality of the covering and structure. Flat roofs can have the advantage of providing an extra area to a building for recreation and an additional viewpoint.

Characteristics of Flat Roof

RC flat roof which is either:

- i. Horizontal or inclined to not exceeding 10 degrees (to prevent ponding).
- ii. Usually surrounded by fascia/ parapet walls.
- iii. In Malaysia, normally constructed for large and tall buildings.
- iv. A concrete slab flat roof is normally made up of a structural layer of concrete finished with a smooth screed onto which a waterproof layer is laid.
- v. The roof should incorporate insulation and usually a vapour control layer to protect from interstitial condensation (condensation in a small gap).

There are two methods of constructing a reinforced concrete flat roof where the waterproofing layer is concerned. Figure 7.7 shows the components of a reinforced concrete flat roof with a waterproofing finish, while figure 7.8 shows the components of a reinforced concrete flat roof with cement and sand screed finish. The latter is also known as the inverted roof.

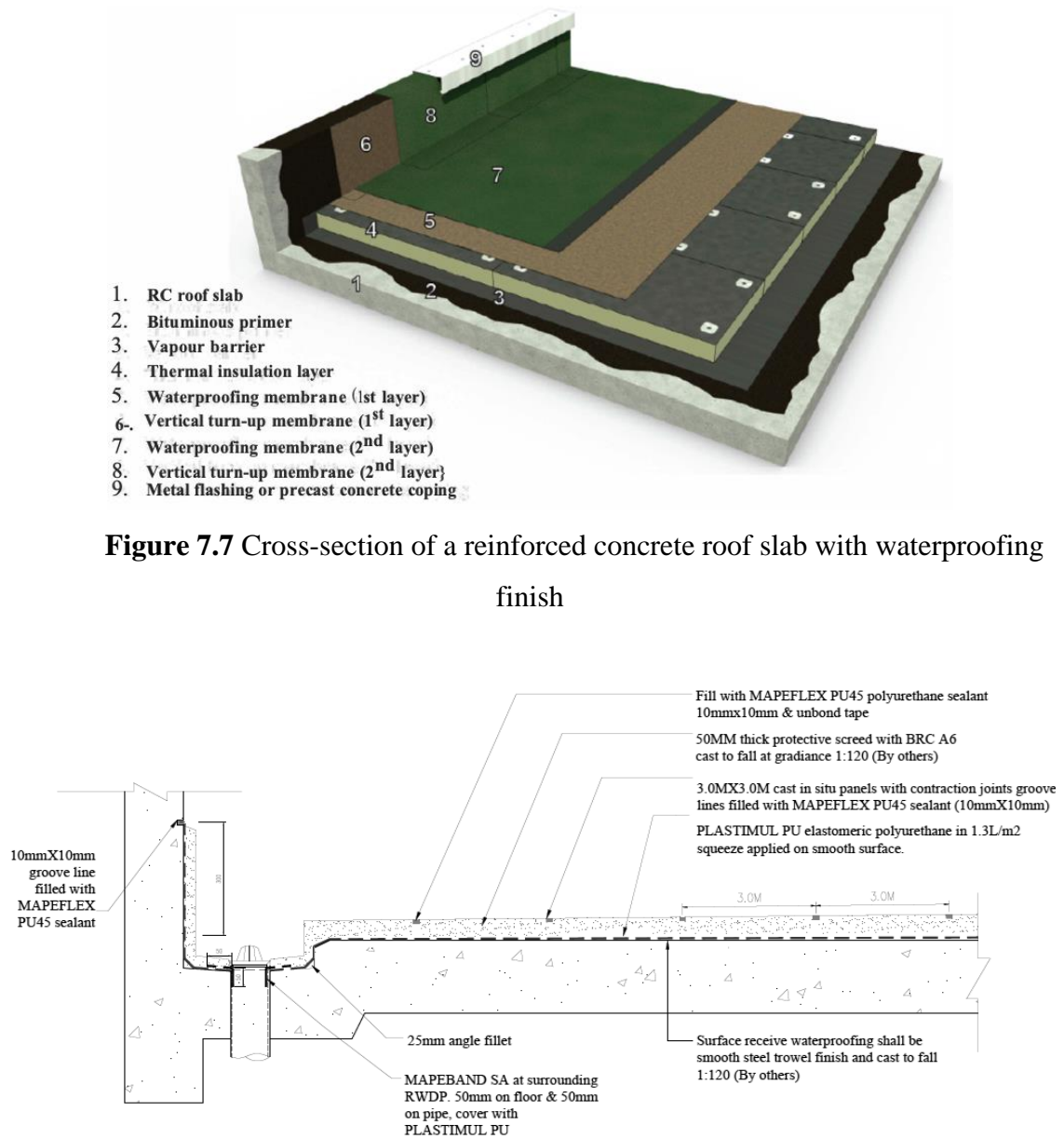


Figure 7.8 Cross-section of a reinforced concrete roof slab with a cement screed finish

WATERPROOFING

Flat roofs are considered a simple form of construction, but they will be an endless source of problems such as leakage unless correctly designed and constructed. Thus, waterproofing is extremely important to the humid tropical climate region like Malaysia. The selection of the waterproofing material can be based on the level of material exposure to the rainwater.

Asphalt Roof Covering

Mastic asphalt provides an ideal covering material for roofs with foot traffic. It consists of an aggregate with a bituminous binder cast into blocks ready for reheating on site. Thus, it is a hot solution application spread over a layer of sheathing felt on a dry screed finish in two layers of 20mm thickness. Then it is covered with dry, fine, sharp sand to absorb the 'stickiness' layer of the asphalt to ease the rendering process. Apart from the hot application, asphalt waterproofing also comes in the form of torch-on membrane and self-adhesive membrane. However, if heavy traffic is expected, the waterproofing layer will be applied beneath the thermal insulation layer instead of above it. This is referred to as an inverted roof.

ROOF COVERING / FINISHES / INSULATION

The covering to any roof structure is fully exposed to rain, snow, wind, sun, and general atmospheric conditions. Therefore, it must have good durability to minimise maintenance work.

Roof Tiles

The conventional covering for pitched roofs in Malaysia is in the form of tiling, especially in residential work. Roofing tiles are manufactured from clay and concrete to a wide range of designs and colours, suitable for roof slopes from 15 to 45 degrees. Its installation requires overlapping or interlocking of tiles; side laps and head laps. This is crucial in preventing water from entering the top of the ceiling area. Figure 7.9 shows the different types and shapes of roof interlocking tiles for specific applications.

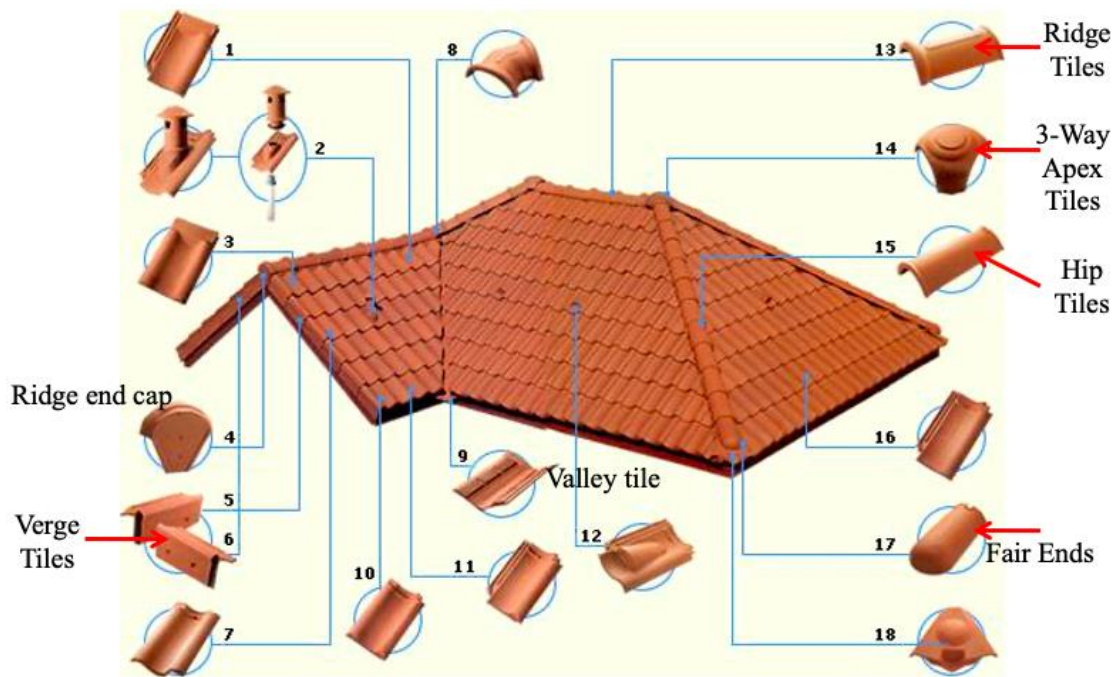


Figure 7.9 Roof tiles and accessories

Roof tiles are fixed to battens using nails, while accessory tiles or special tiles are fixed using mortar. The special tiles such as ridge/hip tiles, apex tiles, valley tiles, eaves/verge tiles are bedded in cement and sand mortar over the general tile surface.

Flashing

Flashing is thin continuous pieces of sheet metal or other impervious material fixed as barriers against the passage of water at angles or joints of a roof. Flashing is installed either exposed or concealed. For exposed flashing, normally a sheet metal such as aluminium and painted galvanised iron are used. On the other hand, concealed flashing may be sheet metal or waterproofing membranes such as bituminous fabric or plastic sheet, depending on the climate.

On the roof, flashing is installed at valleys, next to chimneys, and at the sides of projected gable walls. Figure 7.10 shows the installation of aluminium flashing at the valley.



Figure 7.10 Aluminum flashing at valley

Figure 7.11 shows the details at the valley where galvanised iron flashing is fixed on top of valley rafter and dressed over battens to prevent rainwater from overflowing inside the roof.

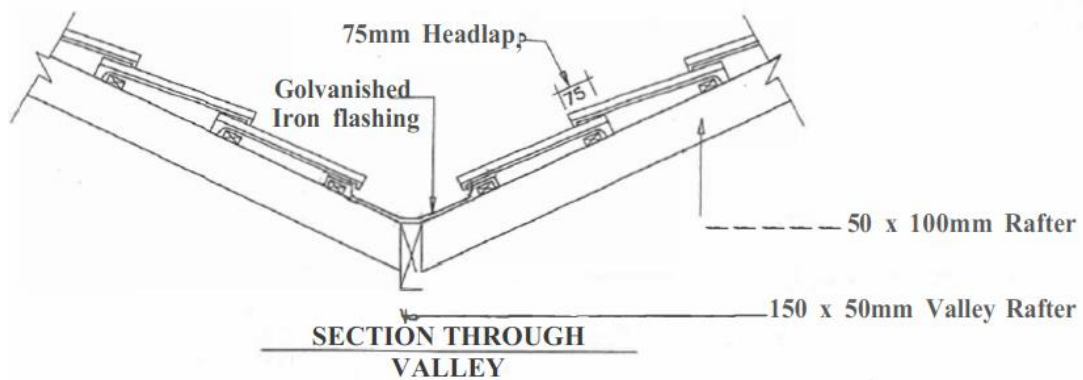


Figure 7.11 Details at valley*

Thermal Insulation

Thermal insulation refers to a barrier to the natural flow of heat from higher temperature to lower temperature. In tropical climates such as Malaysia, the flow is generally from the exterior to the interior of the building. Thermal insulations to a pitched roof and flat roof are different due to the difference in construction components and methods. A building that is well insulated thermally will be more energy-efficient, which will save money for

the owner of the building; the temperatures internally will be more uniform and comfortable, especially when external temperatures are very high or low.

Thermal insulation for pitched roofs in tropical climates is fixed above, between, or below the rafters, as shown in Figure 7.12. Rolls of insulation materials such as single or double-sided aluminium foil, aluminium bubble foil, fibreglass and rockwool are laid across the rafters with the support of chicken wire mesh or straining wires underneath. There are also insulation materials that combine thermal and sound insulation.



Figure 7.12 The installation of thermal insulation membrane

Thermal insulation to reinforced concrete flat roofs can be achieved by using lightweight aggregates or aerated concrete. Generally, lightweight insulating concrete is used in an in-situ screed to the reinforced concrete flat roof.

ROOF DRAINAGE

The main function of roof drainage is to collect rainwater from roofs to a suitable discharge as quickly and economically as possible, thus preventing water penetration to the building interior. Rainwater installation for both pitched and flat roofs consist of gutters connected to vertical rainwater pipes to drains or sewers. Recently emphasis has been placed on recycling the rainwater via storage tanks to flush WCs.

The roof drainage consists of:

- i. Gutterworks (horizontal components)
- ii. Rainwater downpipe (vertical components)

For installation at pitched roofs, gutter components are fixed to the fascia board using brackets. Most gutters are laid with slight falls to encourage flow. The materials available for residential installation are uPVC, galvanised pressed steel, and cast iron. While rainwater downpipes are fixed to brickwall using brackets. For flat roofs, sometimes scuppers are constructed. Scuppers are openings in the parapet wall to drain off rainwater. Apart from gutter/pipes, there are many additional components to be fixed together as shown in the Figure 7.13, 7.14 and 7.15

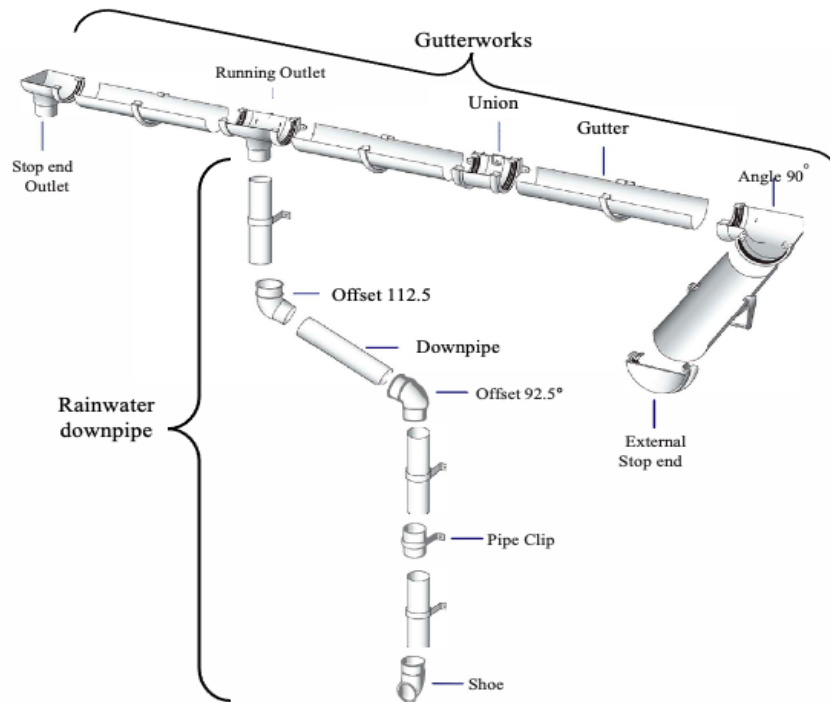


Figure 7.13 Rainwater drainage components; gutterworks and rainwater downpipe

Gutterworks

The section of gutter most commonly used for pitched roofs is the half-round gutter. The sizing of the gutters and downpipes to effectively discharge rainwater depends on the:

- i. The area of the roof
- ii. Intensity of rainfall
- iii. Gutter material
- iv. Number, size and position of outlets

Gutterwork components consist of:

- i. Gutter
- ii. Outlet
- iii. Bend
- iv. Bend with outlet
- v. Stop end
- vi. Stop end with outlet
- vii. Balloon grating



Figure 7.14 Rainwater gutter and fittings

Rainwater Downpipes

Rainwater downpipes will receive water from gutters and transfer it to the perimeter drains at the bottom. The pipes and fittings are fixed to the brickwall using brackets. Components of rainwater downpipe are shown in Figure 7.15, consist of:

- i. Pipes
- ii. Swan neck or bend/offset
- iii. Shoe



Figure 7.15 Rainwater downpipe and fittings

PARAPET WALL

Parapet walls are the outermost walls that are constructed at the edges of the flat roof of the buildings (Figure 7.16). They are commonly constructed above the roof slab level to obscure the roof and for security purposes. It consists of two or three courses of bricks with concrete coping at the top to prevent rainwater from seeping into the parapet wall. However, there are many types of parapet walls based on their material, and this topic only focuses on masonry parapet walls. This wall must be provided with sufficient moisture barriers such as a damp-proof course. Since this wall is free-standing, thus the wall thickness is at least one brick thick to maintain its stability. The wall height depends on its function. Therefore, if it is for security, the height will increase so as its thickness.



Figure 7.16 Parapet wall

CONSTRUCTION OF REINFORCED CONCRETE FLAT ROOFS

Figure 7.17 shows the cross-section of a completed reinforced concrete flat roof with cement and sand render finish. The method and sequence of construction for this type of flat roof are described in Table 7.1.

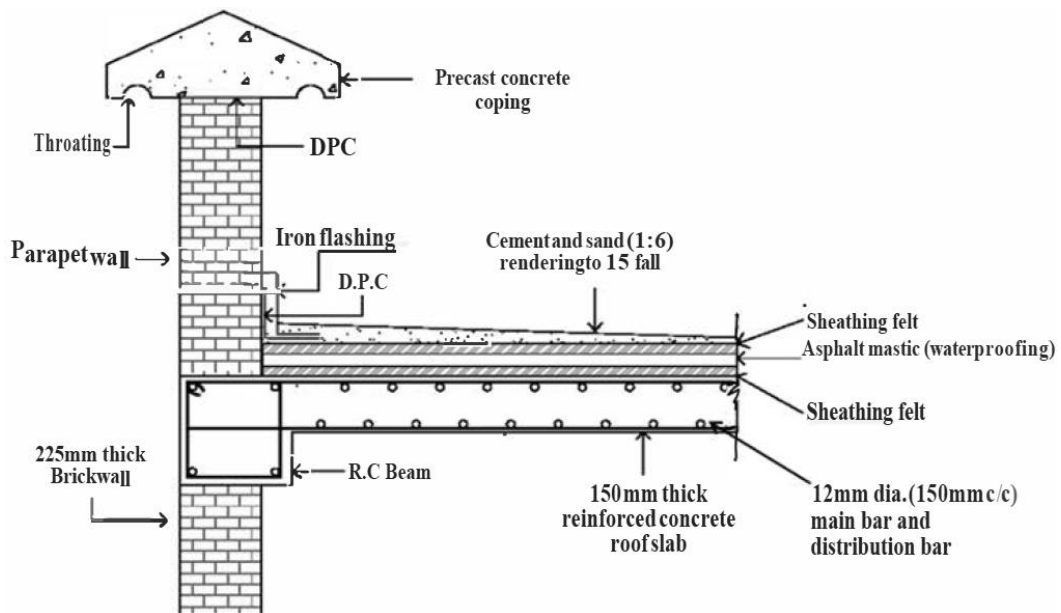




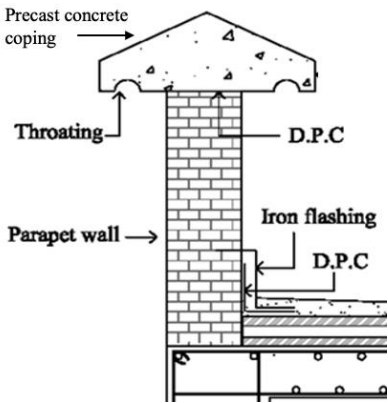

Figure 7.17 Cross-section of RC flat roof with cement and sand render finish




Construction Method and Sequence of a Reinforced Concrete Flat Roof with Cement and Sand Render Finish

This type of flat roof is suitable for high traffic areas such as rooftop parking spaces. Table 7.1 shows the construction sequence for this type of flat roof, also called the inverted roof.

Table 7.1. Construction sequence of the roof

| Construction Sequence | Descriptions | Illustrations |
|---|--|---------------|
| <p>Construct reinforced concrete roof beams and roof slab</p> <p>Erect formwork for roof slab and roof beams (soffit & sides)</p> | <p>Sometimes, it is called shuttering and consists of soffit panels supported by three-sided beam formwork with intermediate propping.</p> | |

| | | |
|--|--|---|
| Lay reinforcement bars | <p>For one-way spanning slabs, the bottom reinforcements are main bars, while the top bars are distribution bars laid across the main bars.</p> <p>For two-way spanning slabs, the top & the bottom bars are the main bars.</p> <p>The bars are laid over and across the beam reinforcement bars.</p> |  |
| Pour concrete | <p>Concrete is poured in the beam formwork first and overflow onto the slab formwork, normally 150mm thick.</p> <p>Compactions using poker vibrators are carried out to remove air bubbles in the concrete.</p> |  |
| Construct parapet wall (concrete or brickwall) | <p>Free-standing parapet walls are erected not less than 1B thick and their height should not exceed 4 times their thickness to maintain stability. Covered with concrete coping at the top. Iron flashing is dressed into the groove in the parapet wall to prevent water from flowing from the wall into the slab.</p> |  |
| Lay sheathing felt | <p>Laid on RC slab as an isolating membrane to protect the waterproofing layer. It is a fibrous membrane that is typically made of fibreglass, polyester, or hessian.</p> |  |

| | | |
|---|--|--|
| Lay mastic asphalt | Depends on the type of waterproofing, it is spread or laid onto the sheathing felt. It may also come in the form of torch-on membranes. |  |
| Lay sheathing felt | Laid the 2nd layer on the dried/cool mastic asphalt layer. |  |
| Cement & sand (1:6) render to fall (at the same time install vertical DPC and iron flashing | Spread and laid to falls to rainwater outlets. Maybe power floated to produce a smooth level surface. Normally 20 mm thick. Then install vertical DPC and iron flashing at the joints between the slab and parapet walls to prevent water seepage. |  |

Construction Method and Sequence of a Reinforced Concrete Flat Roof with a Mastic Asphalt Finish

This type of flat roof is suitable for low-traffic areas where the roof is not accessible to the public. It is because high traffic and loadings may damage the waterproofing layers at the surface.

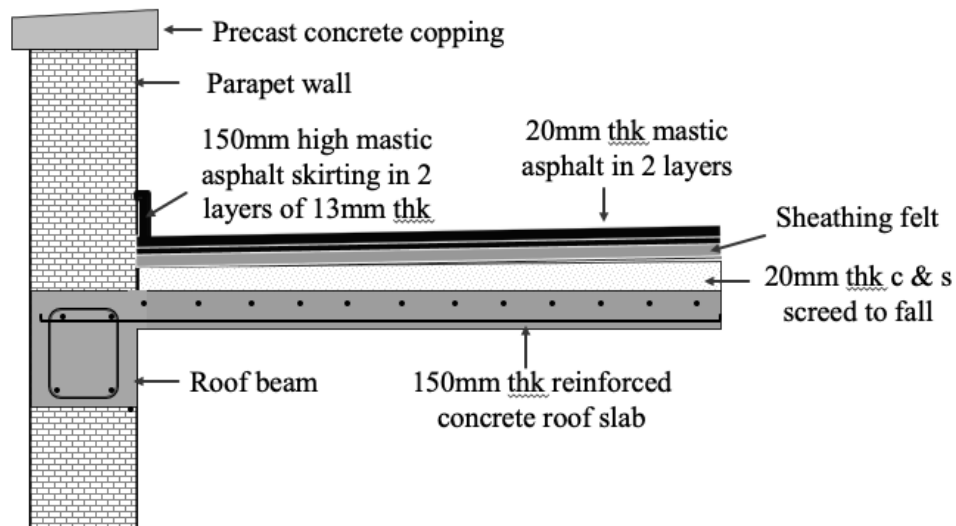


Figure 7.18 Cross-section of a reinforced concrete flat roof with waterproofing finish*

- i. Construct roof beam and roof slab.
- ii. Construct parapet walls.
- iii. Apply cement & sand screed to fall.
- iv. Apply primer (optional)
- v. The Underlay membrane of sheathing felt is laid on cement & sand screed (to fall).
- vi. Hot mastic asphalt mixture is spread in 2 layers of 20mm total thickness. Overlapping is provided to ensure water-tight connections.
- vii. Asphalt skirting 150mm high in 2 layers of 13mm thick at parapet wall/ adjoining wall of a higher building.
- viii. Insert ends of skirting in brickwork (refer to the previous diagram).

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TOPIC 8

BRICKWALL

INTRODUCTION

Wall is an architectural element that encloses or divides the area of a building or space. It is a continuous vertical structure constructed from one column to another. Walls constructed externally at the outer line of a building area are called external walls, having one face exposed to the open air and weather. Internal walls are usually defined as walls that divide rooms or space as opposed to the insides of the external walls. Thus, both faces are exposed to the inner area of a building.

There are many types of wall materials. Brick, concrete, wood, metal, stone, and glass are some of the materials used for wall construction. Factors considered in selecting the wall material are cost, strength, the life of the material, handling and storage, skill required, maintenance, local availability, climate, nature of the project, and aesthetic appeal.

Finishes are also a consideration in wall material selection. Brick and concrete walls required a finished surface, usually consist of plaster and paint. Holes on the wood surface need to be concealed with filler before painting. Metal must be free from dust before it gets painted. While stone and glass need no finishes as these two materials are finished ready components.

The most common material used for walls is brick. The earliest walls were made from mud bricks held together by a thin mud slurry, some of which have proved to be surprisingly resilient. A contemporary brick wall is typically made of clay, concrete, or calcium-silicate bricks.

THE BRICKWALL CONSTRUCTION

The term brick means a block composed of dried clay but is now also used informally to denote other chemically cured construction blocks. Clay is a type of fine-grained natural soil material containing clay minerals. Clays develop plasticity when wet due to a molecular film of water surrounding the clay particles but become hard, inelastic, and non-plastic upon drying or firing. The following are explanations of brick material and types of brick.

BRICK MATERIAL

Most pure clay minerals are white or light-coloured, but natural clays comprise various colours from layers such as reddish or brownish colour due to small amounts of iron oxide. There are three basic types of brick production, unfired, fired, and chemically set bricks. Each type is manufactured differently.

Unfired bricks are made from wet, clay-containing soil mixed with grass or similar binders. They are air-dried until ready for use. Fired bricks are burned in a kiln, which makes them durable.

Modern, fired clay bricks are formed in one of three processes – soft mud, dry press, or extruded. Chemically set bricks are not fired but may have the curing process accelerated by applying heat and pressure using a special heating machine.

The brick that is widely used in Malaysia is fired brick. Some advantages of fired bricks are economical, readily available in the market, requiring only common skill, sustainability, and energy efficiency.

Bricks can absorb heat during hot weather and retain heat during rain or cold temperatures. Thus, this can help create a comfortable atmosphere in a building and reduce air conditioning usage.

TYPES OF BRICK

The typical brick size used in Malaysia is per British Standard. The size is 215mm long x 102.5mm wide x 65mm high. Figure 8.1 shows the brick dimension. The shape of clay bricks is either solid common brick, core holes brick, or frog brick.

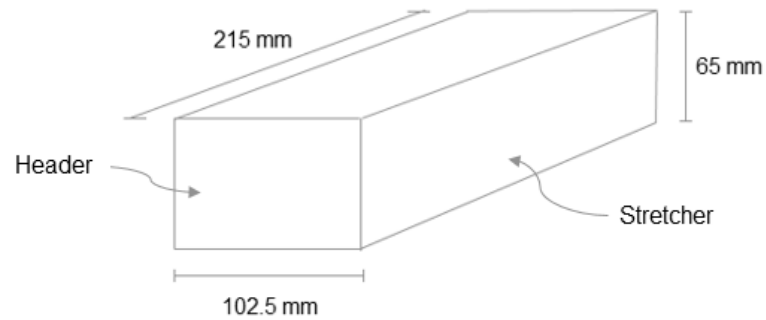


Figure 8.1 Brick Dimension*

Solid common bricks are rectangular. Core holes brick has holes along the brick length. Frog bricks are bricks with a recess on the top of a brick.

Bricks are stacked on a wooden pallet for easy handling and safeguarding it before transporting it from the factory to hardware stores or construction sites. Figure 8.2 shows the three clay brick shapes.



Figure 8.2 Clay brick shapes

BRICKLAYING PROCESS

Bricks are usually bounded by 10mm thick cement and sand mortar or lime mortar. Cement and sand mortar is a mix of Portland cement, fine sand, and water, while the lime mortar is from dry lime powder, additive material, and water.

Cement and sand mortar is typically used to join the brick. The proportion of cement and sand mortar varies from 1:3 to 1:6 or as specified. Figure 8.3 shows the process of applying mortar during bricklaying work.



Figure 8.3 Mortar in bricklaying process

After understanding the basic knowledge of bricks, next is the construction of brickwall. Figure 8.4 shows steps in the bricklaying process. There are four stages: setting brick lines, cutting the bricks, applying the mortar, and finishing the brick surface.

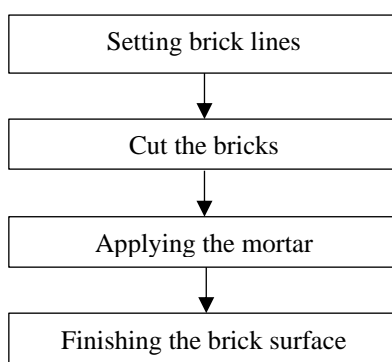


Figure 8.4. Bricklaying process

The first step of masonry work or brickwork is setting the brick line or mason line. A mason line acts as a guide for setting bricks in perfectly straight rows. It is made of two bricks with slots to hold a mason line.

Affix the bricks to either end of the row of bricks, with the line pulled tight. The top of each brick in the row should touch the top of the line.

The setting process also can use a strip of wood that acts as a guide for laying bricks. Use a pencil to mark the height of each course of bricks, including the mortar joints, on the wood strip. Setting bricks lines showed in the following Figure 8.5.

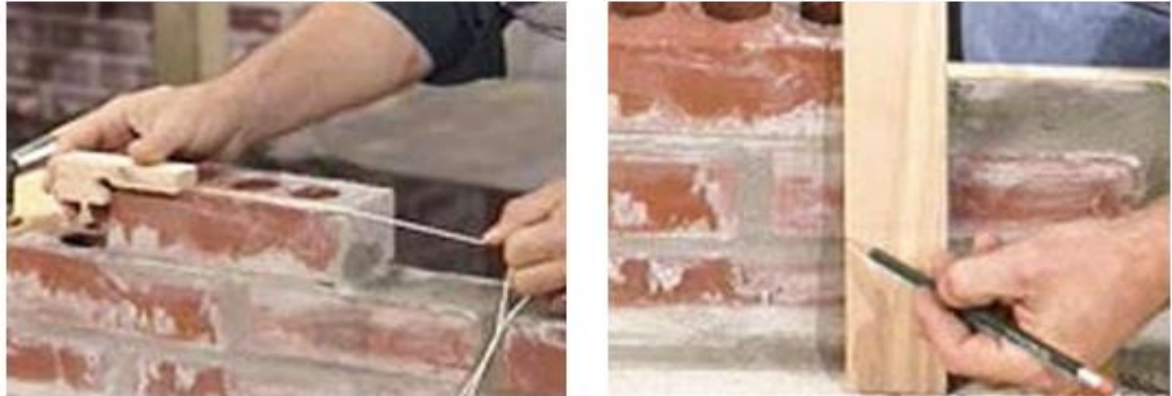


Figure 8.5 Setting bricks lines

The next process is to cut the brick. Most walls require smaller bricks depending on the bonding pattern. Before cutting a brick, place it in a bed of sand or dirt to absorb the shock of the cutting. Place the sharp end of a brick chisel at the line to cut. Use a hammer to tap the end of the chisel, scoring lines on all four sides where the brick must be cut.

The process continues by applying the mortar. A spade trowel is used to apply an amount of mortar to each layer of brick. Score a line through the center of the pile of mortar to allow it to spread.

Grease the brick with mortar, spreading mortar on the sides that will affix to the bricks beside them. Use the handle of the trowel to knock each brick into place and release any air bubbles in the mortar underneath. Figure 8.6 shows the brick cutting and mortar applying process.



Figure 8.6 Brick cutting and mortar applying process

When bricks especially core holes brick and frog brick are laid in a bed of mortar, the mortar squeezes into the holes of which, when dried, locks the bricks into place. When the entire wall is built, the individual bricks are part of a wall system where single brick cannot move without putting tension on surrounding bricks. This gives the entire wall structure a better strength.

The final step is to finish the brickwork surface. Remove all the surplus mortar by using the sharp end of the trowel, scrape off any excess mortar that spreads beyond the joint, as shown in Figure 8.7.

Finish cleaning off any other debris with a brush. Holding a spade trowel at a 30-degree angle, carve small lines between bricks and mortar. The lines will help protect the wall from the effects of rain and weather.



Figure 8.7 Cleaning the brick surface

Brickwork should be carried out for not more than 1 meter or 3 feet in height at a time. When one part of the wall has to be delayed, stepping should be left at an angle of 45 degrees. Corbelling or projections, where made, should not be more than $\frac{1}{4}$ brick projections in one course. All joints should be raked, and the wall faces are cleaned at the end of each day's work.

BRICK BONDING PATTERN

The brick bonding process or bricklaying work carries out according to architectural drawing. The architect mentions the arrangement of brick to be jointed or bonded. This is called the brick bonding pattern. The purposes of brick bonding patterns are to distribute loads throughout the structure to achieve maximum strength, ensure stability, and achieve the desired aesthetic.

Bricks are typically laid to an offset pattern to maintain an adequate lap between joints from one course to the next and ensure that vertical joints are not positioned above one another on consecutive courses. Several types of brick bonding patterns usually apply in masonry work in Malaysia:

- i. Stretcher Bond
- ii. English Bond
- iii. Flemish Bond
- iv. Header Bond

Each bonding pattern has its characteristics and brick layout. Different bonding patterns require different numbers of bricks in every square meter. It also creates a different wall façade, wall thickness, and strength.

Stretcher Bond

Stretcher bond is the most commonly used bond in the United Kingdom and Malaysia. Stretcher bond is the term given to the repeating pattern of the bricks are laid in.

This pattern is made only using stretchers (brick-laid length-wise). The joins on each course centered above and below by half a brick. The vertical joints are staggered each time by half a brick. No two adjacent vertical joints should be in line. For a straight wall, just offset each course by half a brick. Figure 8.8 shows an elevation of the stretcher bond pattern.

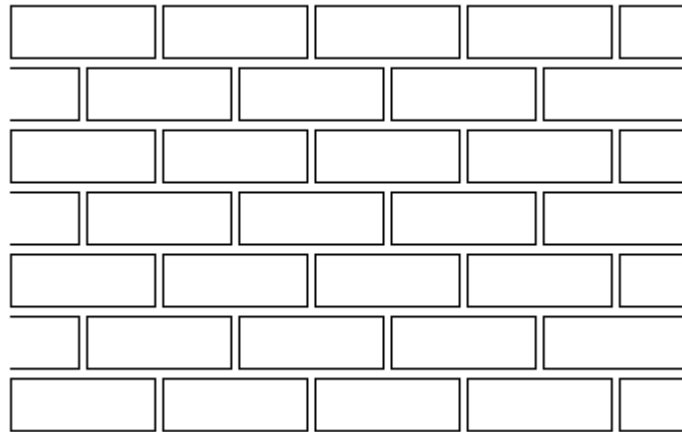


Figure 8.8 Elevation of Stretcher Bond Pattern*

The stretcher bond wall is usable in half brick wall settings. This is because it is only as thick as one-half of a brick. There is almost no loss of material because the bricks do not have to be cut to size.

English Bond

English bond is a pattern of one brick wide. This pattern is formed by laying alternate courses of stretchers and headers. The joins between the stretchers are centered on the headers in the course below.

No two adjacent vertical joints should be in line. This is one of the strongest bonds but requires more bricks than other bonds. Figure 8.9 shows an elevation of the English bond pattern.

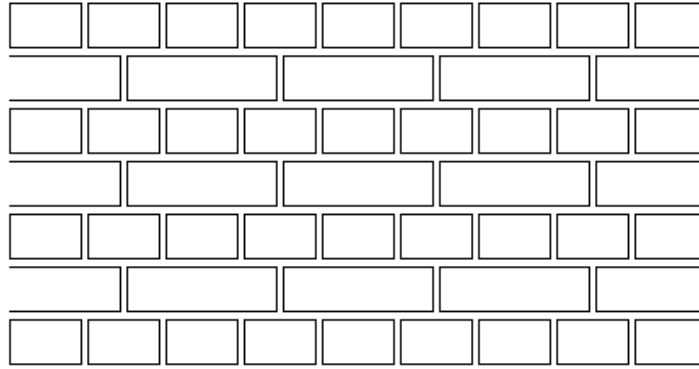


Figure 8.9 Elevation of English Bond Pattern*

English bond is considered stronger than other bonds, so it is suitable to be used for civil engineering projects such as bridges, viaducts, and embankments.

Flemish Bond

The traditional Flemish bond has alternate stretchers and headers on every course, with the headers centered over the stretcher's underneath. Alternate courses start with stretcher and header.

To break the vertical joints queen closers are required if a course starts with a header. Every header is centrally supported on the stretcher below it.

Flemish bonds can be replicated in the half-brick outer leaf of a cavity wall by using whole bricks as stretchers, while the headers are created by half bricks called bats or snap-headers. Figure 8.10 shows an elevation of another Flemish bond pattern.

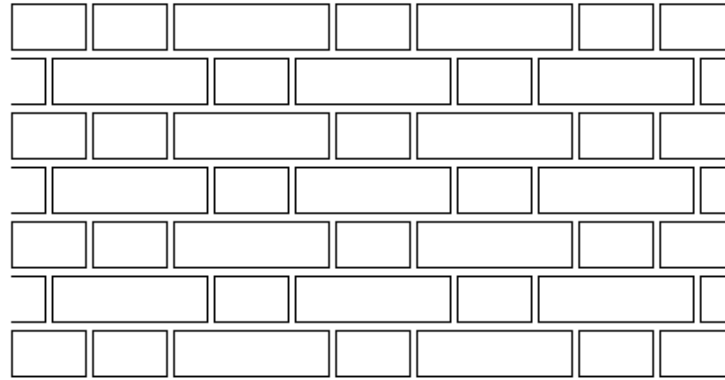


Figure 8.10 Elevation of Flemish Bond Pattern*

Header Bond

The header bond pattern, all bricks are arranged in the header courses. This type of bond is useful for the construction of one brick wall. This bond uses so many bricks that it is usually reserved for very high-quality buildings. It can also be used for radial brickwork, as the header faces can accommodate smaller radii. It is often employed with contrasting brick colors to give a decorative effect. A header is the shorter face of the brick, as seen in the elevation of Figure 8.11. This type of bond is useful for the construction of one brick thick wall.

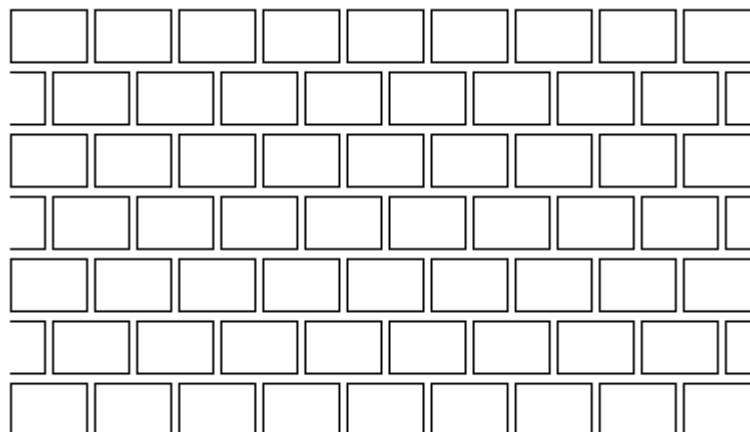
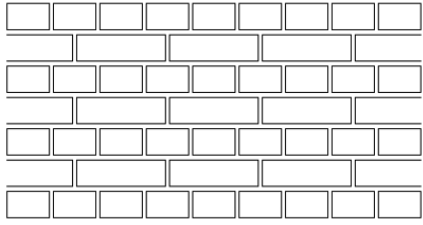
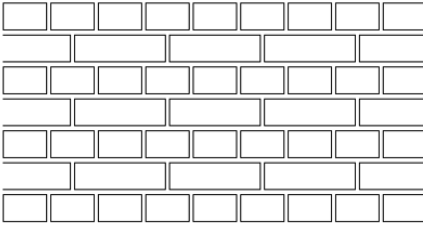
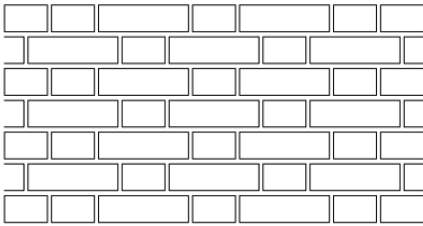
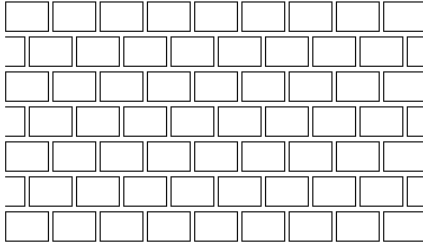


Figure 8.11 Elevation of Header Bond Pattern*

Table 8.1 Brick bonding summary*

| No | Brick Bonding Pattern | Description |
|----|--|---|
| 1 | Stretcher Bond  | <ul style="list-style-type: none"> Using stretchers (brick laid lengthwise). The joints on each course centered above and below by half a brick. No two adjacent vertical joints should be in line. |
| 2 | English Bond  | <ul style="list-style-type: none"> Laying alternate courses of stretchers and headers. The joints between the stretchers are centered on the headers in the course below. No two adjacent vertical joints should be in line. |
| 3 | Flemish Bond  | <ul style="list-style-type: none"> Alternate stretchers and headers on every course. Headers centered over the stretcher's underneath. Alternate courses start with stretcher and header. |
| 4 | Header bond  | <ul style="list-style-type: none"> All bricks are arranged in the header courses. Uses many bricks; hence it is usually reserved for very high-quality buildings. It can also be used for radial brickwork, as the header faces can accommodate smaller radii. |

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* Sukmawati Ismail

TOPIC 9

DOOR AND WINDOW

INTRODUCTION

Door and window are architectural elements that serve the main function of the building. Door is a movable barrier which provides access to the inside spaces or rooms of a building. Door also functions as a barrier to secure an opening and allows people and goods movement throughout the building. Besides that, door also gives an aesthetic purpose to the building.

Window is defined as an opening on the wall to serve functions such as natural lighting, natural ventilation, and vision. Windows are also designed for architectural decoration. Window, which transmits light from outside, is normally constructed using translucent and see-through material such as glass.

Both door and window have similar functions in providing access to the building, allowing light and air circulation, space partition, and keeping the privacy and security of the building users. Door and window material and design must cater for durability, safety, thermal efficiency, and style and aesthetic aspects.

Door and window have a number of different features, designs and materials used. Timber, metal, aluminium, glass and unplasticized polyvinyl chloride (UPVC) are some of the materials used for door and window. Many factors contribute to the selection of the door and window design and material, such as function, location, maintenance, and climate condition.

DOOR CONSTRUCTION

Door system is held in position by two elements, door frame and door leaf. A door frame is a set of horizontal and vertical members joined together to form an enclosure to which door leaves are fixed. Door leaf is a moving panel that fills the entire doorway space and is attached to the door frame.

DOOR FRAME

Door frame must have enough strength to cater to door loads and upper loads. Door framing installation requires accuracy and skill in fixing mortises and dovetails. This is because the door system needs a very accurate size and settings to ease the installation. It is also to ensure the door installed meets the specification to suit its function, position, security, and durability of the door:

- i. Normal door opening is 900mm x 2100mm high to allow movement of users, furniture, and goods
- ii. Door frame must be weather resistant (external door) and water resistant (internal door for wet areas such as bathroom and kitchen)
- iii. Material for door frame is normally from timber, steel and aluminium
- iv. Vertical members in door frame are called jambs or posts, normally at 150mm x 40mm thick in size
- v. Horizontal members are known as head also at 150mm x 40mm thick in size
- vi. Horizontal projection at the head is called horn

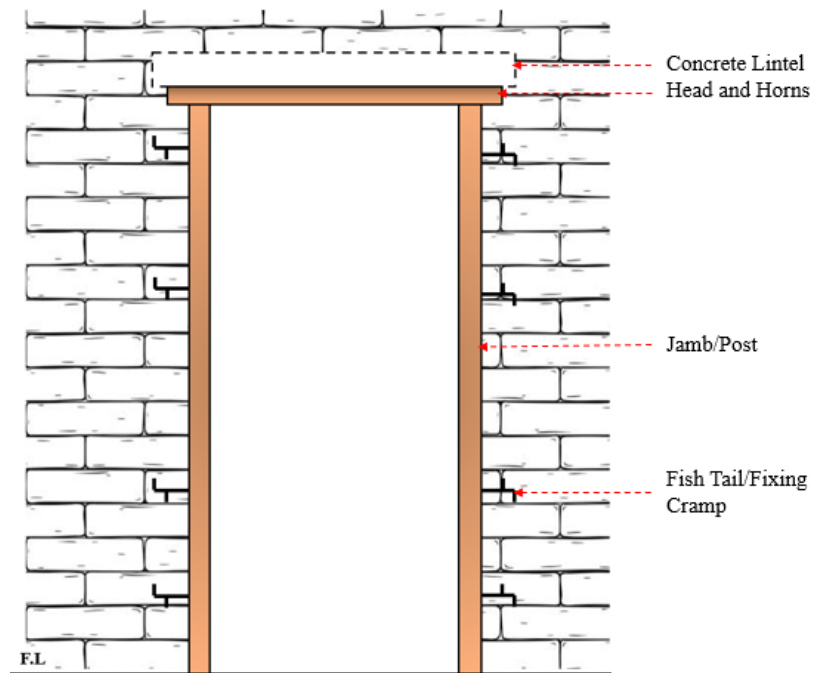


Figure 9.1 Door frame components*

Heel stone is fixed at the bottom of door frame (timber frame) for wet area door to avoid timber rot.

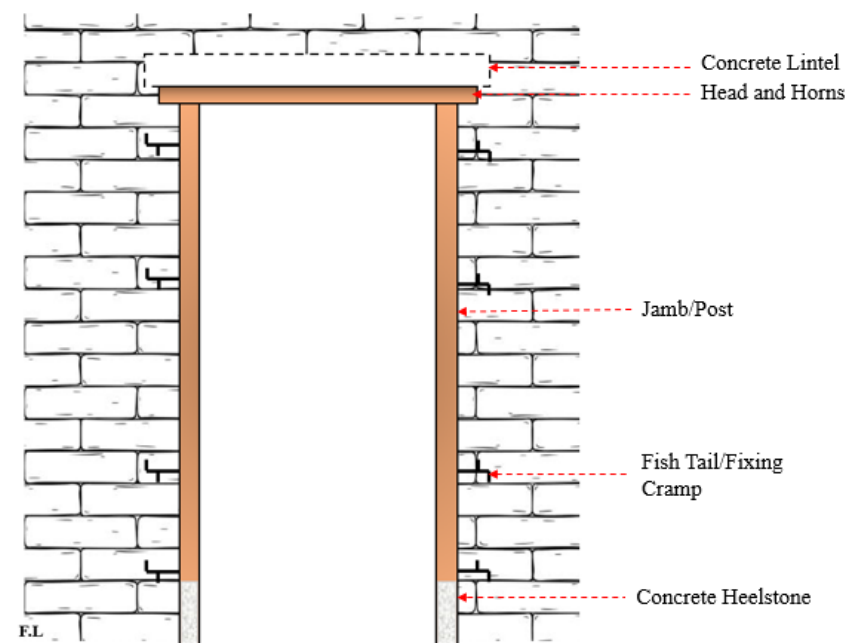


Figure 9.2 Heelstone at timber door frame*

A rebate cut of about 12mm is provided around the frame to receive door leaf. The rebated frame functions as a stopper as it catches the door when the door is closed and can only be opened one way.

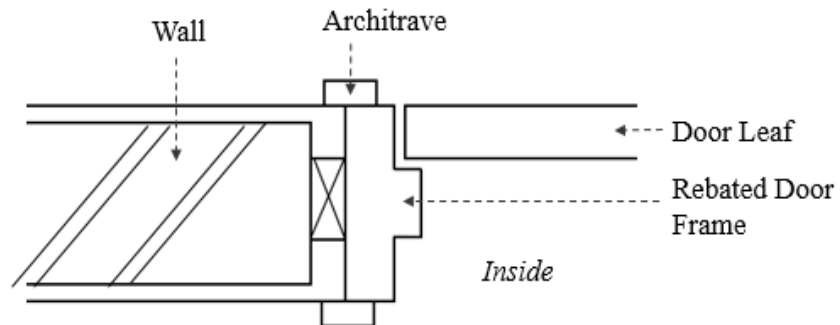


Figure 9.3 Door frame section*



Figure 9.4 Sample of rebated door frame section*

Architrave is a component that covers the joint between the wall and door frame. It is more to add aesthetic features to the whole door system.

DOOR LEAF

Door leaf is a moving panel that fills the entire doorway space and is attached to the door frame. There are many ways of fixing a door leaf to the door frame, such as hinged, sliding,

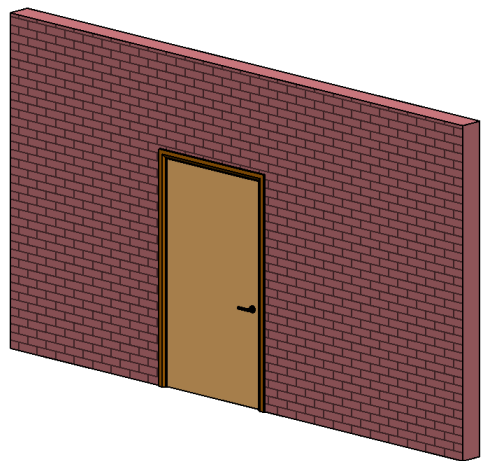
swing, folded, collapsible and rolling shutter. There are also various types of door leaf available in the market:

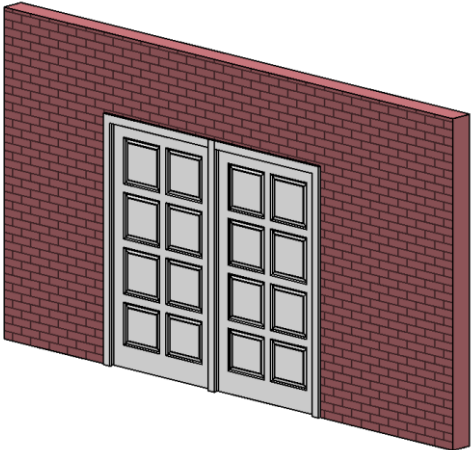
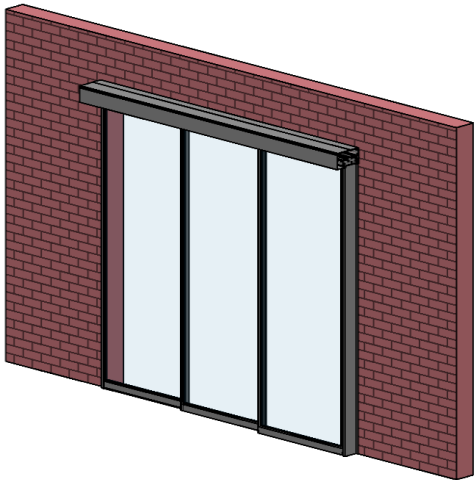
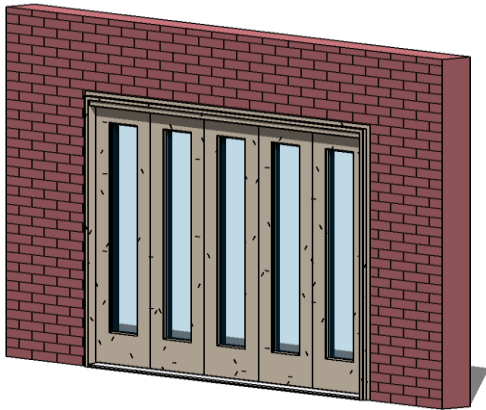
- i. Most doors are fixed or hinged along one side of a frame to allow the door to swing in one direction.
- ii. The axis of door swing is usually vertical. The operation of the hinged door is simple and rigid.
- iii. Hinged door requires minimal maintenance and cleaning but take up room space to swing in.
- iv. The detailed door type is discussed in door type.

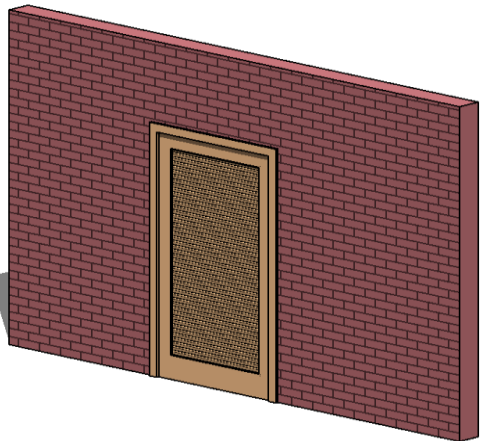
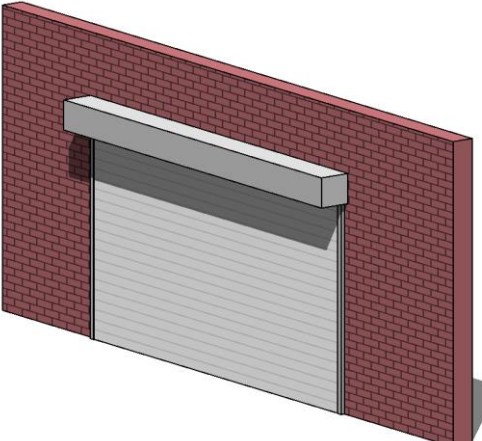
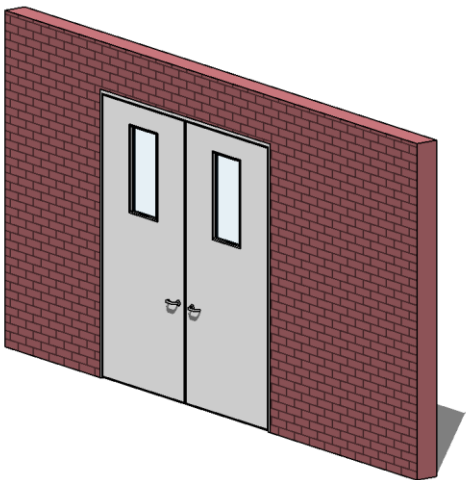
DOOR TYPE

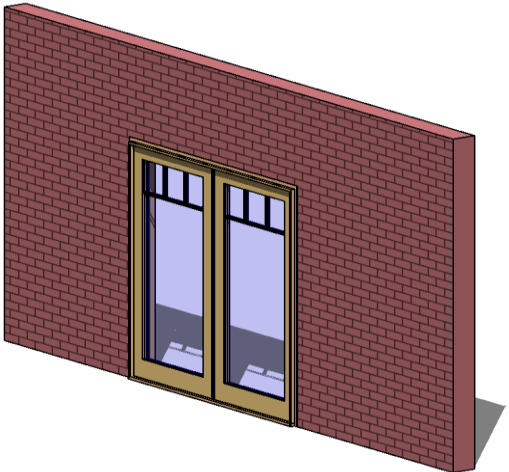
Many types of door are commonly used in Malaysia, such as flush door, panel door, sliding door, folding door, louvered door, roller shutter door, fire door, and composite door. Each type comes in either timber, metal, aluminium, glass or unplasticized polyvinyl chloride (UPVC). Table 9.1 shows the detail of each door type.

Table 9.1 Door types*

| Types of Doors | Description | Illustration |
|----------------|--|--|
| Flush Door | <ul style="list-style-type: none"> ● Flush door is a simple design which has plain facings on both sides of the door. ● Fixed at side hinges. ● This type of door leaf is mainly constructed with timber framing by using two sections of plywood attached to each side of a frame. ● The interior of the door is hollow and sometimes filled with softwood. ● Flush doors are suitable to be used as interior and exterior doors. ● UPVC flush door is used for toilet, bathroom and wet area |  |

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| <p>Panel Door</p> | <ul style="list-style-type: none"> ● Panel door is constructed with panels, usually shaped to a pattern and rails that form the outside frame of the door. ● Fixed at side hinges. ● This door type is strong and gives a better appearance than flush doors and is normally from solid hardwood timber. ● A panel door is the most popular door and is normally used for exterior doors as its aesthetic and appearance are suitable for those purposes. |  |
| <p>Sliding Door</p> | <ul style="list-style-type: none"> ● Sliding door is a type of door which opens horizontally by sliding and is usually parallel to a wall. ● It is opened by sliding sideways inside of the opening into a room. ● Sliding doors are commonly made of glass panels with aluminium or metal framing. ● This type of door is a good space-saver since no leaf swings inside the area and is suitable to be used as an exterior door. |  |
| <p>Folding Door</p> | <ul style="list-style-type: none"> ● Folding door is a door constructed from two or more hinged leaves that can be folded against another. ● Top and bottom rails of a door hold the panel to ease the folding system. ● The door panels can be folded or unfolded to open and close the door. ● It is normally from timber, metal, glass or UPVC material. ● It sometimes functions as an internal partition for halls that divides into rooms. |  |

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| <p>Louvred Door</p> | <ul style="list-style-type: none"> • Louvred door has some part of it filled with louvres fixed to framing. • Normally from timber material, and sometimes the louvres come in metal or aluminium blades. • This door allows air to pass through while the door is closed. • Louvred door is normally used as a closet door, store and any room with humidity element. |  |
| <p>Roller Shutter Door</p> | <ul style="list-style-type: none"> • Roller shutter door is a door constructed from individual horizontal steel or aluminium slats. • It is operated by rolling the slats around a barrel directly up or down with the assistance of either a spring or an electric motor (or both). • The rails and guides are also provided along the frame sides to hold the curtain securely in place. |  |
| <p>Fire Door</p> | <ul style="list-style-type: none"> • Fire door is a safety building component manufactured to very specific guidelines to give occupiers of a building more time to escape in a fire. • Fire door is used as part of a passive fire protection system to reduce the spread of fire and smoke between building compartments. • It is constructed with high quality timber base material which is treated with fire retardant finishes. • There are many specifications for fire door. • The door can hold back fire and flame for 30 minutes (FD30) or 60 minutes (FD60) • FD30 or FD60 doors are certified under British Standard BS 476 Part 22 or the European equivalent BS EN 1634 • Fire door is heavier and thicker than regular internal doors, equipped with |  |

| | | |
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| | fire-rated hinges, fire-rated door frames, and coated with sealing strips to ensure the fire protection rating of the door. | |
| Composite Door | <ul style="list-style-type: none"> • A composite door is a door that is made from a mixture of materials to give strength and durability to its construction. • Doors of this make-up include a solid timber or a particle board core which is set inside a wooden frame and faced with a glass reinforced polymer (GRP) coating. • Composite doors are normally used as exterior doors for the aesthetic and traditional wooden door appearance. • It requires less maintenance and has thermal efficiency. |  |

DOOR INSTALLATION

Carpenter or manufacturer's personnel carries out the door installation. The following are steps for door installation.

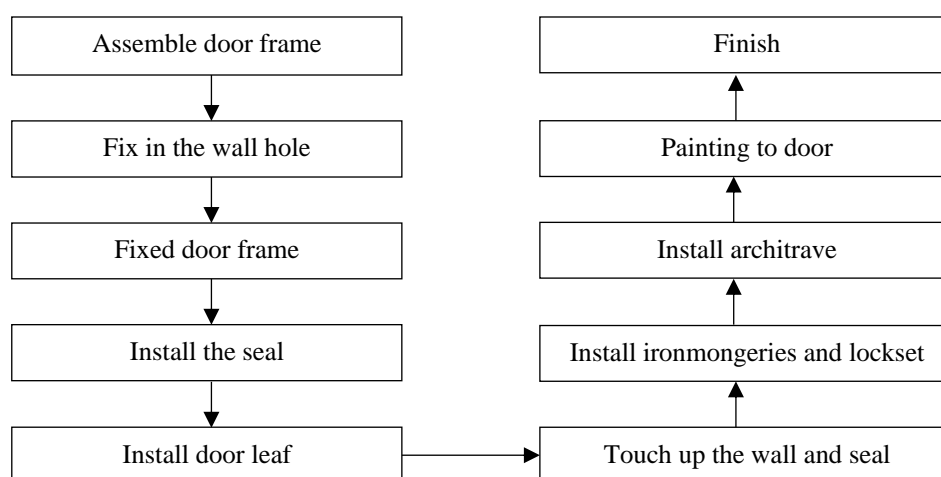


Figure 9.5 Door installation steps

- Door installation starts with the frame assembling process. Sometimes, the door frame comes in a complete set from the factory.

- ii. Then, the door frame is fixed in position to the wall opening, which the bricklayer sets.
- iii. Wall opening is wider than actual size of a door to allow the fixing process.
- iv. Levelling and setting must be accurate to ensure the door is fixed in the right position.
- v. Door frame is fixed to the wall by screwing the metal fixing cramp and the frame to the wall.
- vi. Temporary spacer and stretcher are used to prevent inward sagging and the frame from being squeezed in during fixing. Refer to Figure 9.6.
- vii. Gaps between frame and wall surface are also fixed with brick or concrete sealer to ensure the door frame is at the right position as set earlier.
- viii. Door leaf will be placed and hinged to the frame when the frame is stable and in the right position.
- ix. After the frame and door leaf are fixed, the gap will be finished and filled with concrete mortar or brick.
- x. Ironmongeries and locksets are then fixed to the door.
- xi. Architrave is then screwed to the wall between the frame and wall joints to cover the line.
- xii. Painting to the frame and door will be carried out after all is in place.

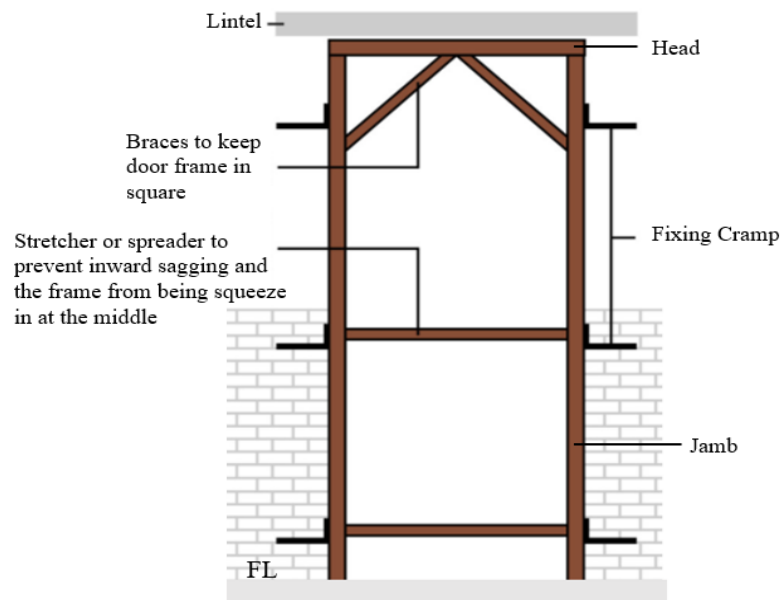


Figure 9.6 Door frame erecting struts*

WINDOW CONSTRUCTION

Windows opening on the wall allows light and air admission. The window system is similar to door, consists of two elements, window frame and window leaf. A window frame is a set of horizontal and vertical members joined together to form an enclosure to which window leaves are fixed. Window leaf is a moving panel that fills the entire window opening and is attached to the window frame.

WINDOW FRAME

There are various sizes of windows, such as 600 x 1200mm high (single panel), 1200 x 1200mm high (double panels) and 1800 x 1200mm high (three panels). Window frames must be weather resistant as they are exposed to the outside temperature. Material for window frames are normally made from timber, steel and aluminium. Vertical members in window frames are called jambs and mullions, normally at 150mm x 40mm thick in size. Jambs are the outer vertical frame of a window, while mullions divide the vertical frame into 2 or more window panels. The standard size of a frame is 150mm x 40mm thick. Heads are top horizontal members of a window frame, and transoms are horizontal members that divide the panel into smaller panels above the window, such as top hung windows or vents. Figure 9.7 shows the detail for the window frame.

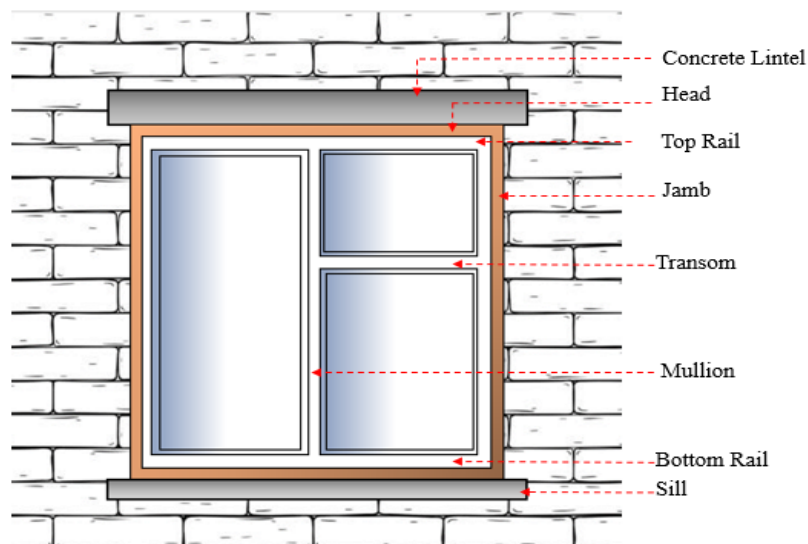


Figure 9.7 Components of window*

WINDOW LEAF

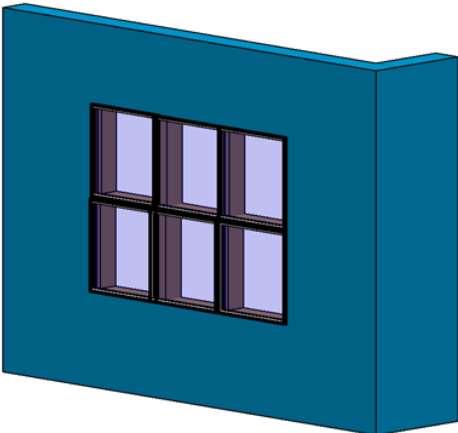
Window leaf or window shutter is a translucent panel where sunlight can enter the interior space of a building. It is also defined as a panel that fills the entire window space and is attached to the window frame. The window leaf is normally made of glass. Clear, tinted, and tempered glass are used for window leaves.

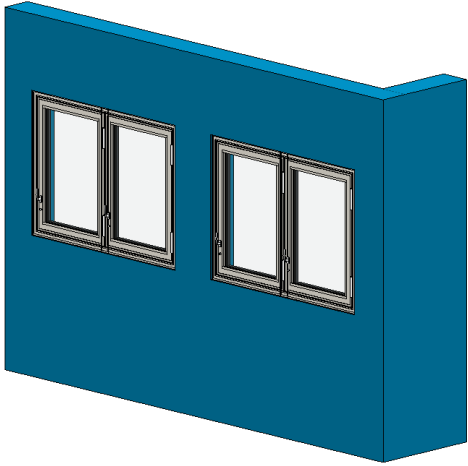
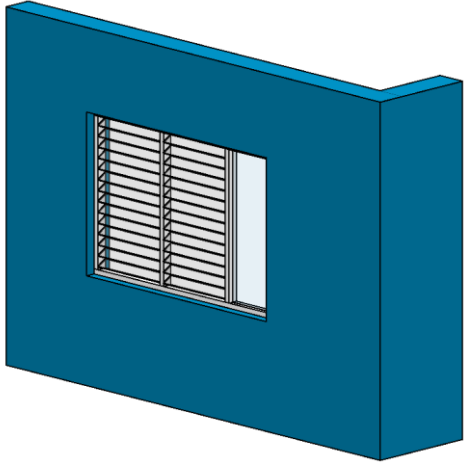
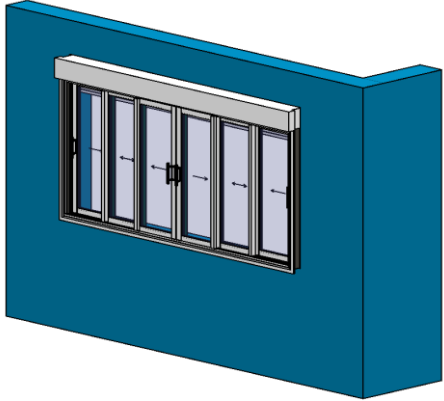
There are many ways of fixing a window leaf to the window frame, such as hinged, sliding, and swing windows. There are also various types of window leaf available in the market. The detailed window type is discussed in 9.3.3.


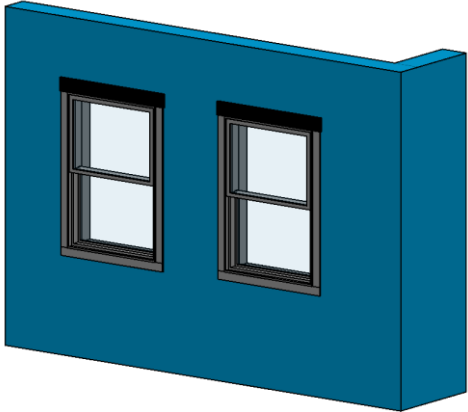
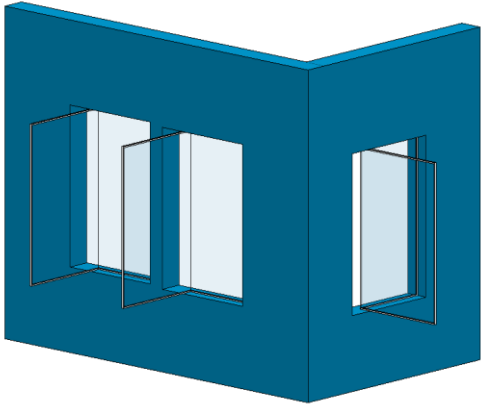
WINDOW TYPE

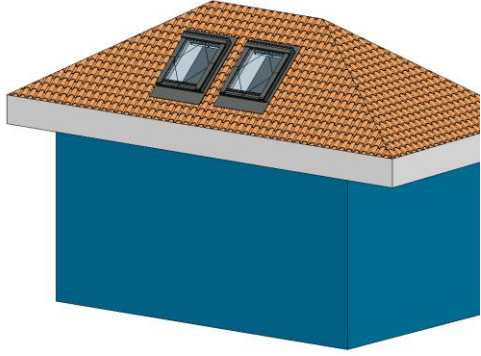
Many types of windows are commonly used in Malaysia, such as fixed window, casement window, louvered window, sliding window, top hung window, double hung window, pivoted window, and lantern window. Each of the types comes in either timber, metal, aluminium with glass as window leaf. Table 9.2 shows the details of each window type.

Table 9.2 Window types*

| Types of Window | Description | Illustration |
|-----------------|---|--|
| Fixed Window | <ul style="list-style-type: none">▪ Fixed windows are fixed to the wall without any closing or opening operation.▪ In general, they are provided to transmit light into the room.▪ Fully glazed shutters are fixed to the window frame.▪ Normally, it is installed on the top of a window set to enable extra lighting in entering the building.▪ The shutters provided are generally weatherproof. |  |

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| <p>Casement Window</p> | <ul style="list-style-type: none"> ▪ Casement windows are common windows that are widely used nowadays. ▪ The shutters are attached to the frame, and these can be opened and closed like door shutters. ▪ Rebates are provided to the frame to receive the shutters and allow the shutters to move one way. ▪ The panels of shutters may be single or multiple. Sometimes wired mesh is provided to stop insects from entering the building. |  |
| <p>Louvred Window</p> | <ul style="list-style-type: none"> ▪ Louvred windows are similar to louvred doors, which provide ventilation without any outside vision. ▪ The louvres may be made of wood, glass or metal. ▪ Louvres can also be folded by the provision of cord over pulleys. ▪ Users can maintain the slope of louvres by tilting the cord and lifting the cord. ▪ Recommended angle of inclination for louvres is about 45 degrees. ▪ The sloping of louvres is downward to the outside to run off the rainwater. ▪ Generally, they are provided for bathrooms, toilets and rooms with humidity elements. |  |
| <p>Sliding Window</p> | <ul style="list-style-type: none"> ▪ In this case, window shutters are movable on the frame. ▪ The movement may be horizontal or vertical based on design requirements. ▪ The movement of shutters is done by the provision of roller bearings on the window frame. ▪ Generally, this type of window is widely used as it can save space because there is no swing of a window leaf into the room. |  |

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| <p>Top Hung Window</p> | <ul style="list-style-type: none"> ▪ Top hung window is a window panel hinged at the top of a window frame. ▪ Shutter can be opened by pushing the panel outward. ▪ Attached to the top of the window panel ▪ Normally, it is installed and attached on the top of a window set in enabling extra lighting and ventilation to enter the building. |  |
| <p>Double Hung Window</p> | <ul style="list-style-type: none"> ▪ Double hung windows consist of a pair of shutters attached to one frame. ▪ The shutters are arranged above one and another. ▪ These two shutters can slide vertically within the frame. ▪ So, users can slide open the windows from the top or bottom to their required level. ▪ A chain or cord consisting of metal weights connected over pulleys is provided to operate the double hung windows. ▪ Then, by pulling the weighted cord the shutters can move vertically. ▪ Users can fix the windows at their required position for ventilation or light. |  |
| <p>Pivoted Window</p> | <ul style="list-style-type: none"> ▪ Pivots are provided to window frames. ▪ Pivot is a shaft which helps to oscillate the shutter. ▪ No rebates are required for the frame. ▪ The swinging may be either horizontal or vertical based on the position of pivots. ▪ Pivoting windows are a type of window with sashes that can rotate 90°-180° around a horizontal or vertical axis, usually located on or near the centre of the sash. ▪ The rotation of a pivoting window allows for full ventilation but cannot be equipped with a screen for filtering. |  |

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| Lantern Window | <ul style="list-style-type: none"> ▪ Lantern windows are provided for over the roofs. ▪ The main purpose of this window is to provide more light and air circulation to the interior rooms. ▪ Generally, they are projected from the roof surface. So, users can close the roof surface when required. |  |
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WINDOW INSTALLATION

Carpenter or manufacturer's personnel carries out the window installation. The installation is almost similar to door installation. The following are steps for window installation.

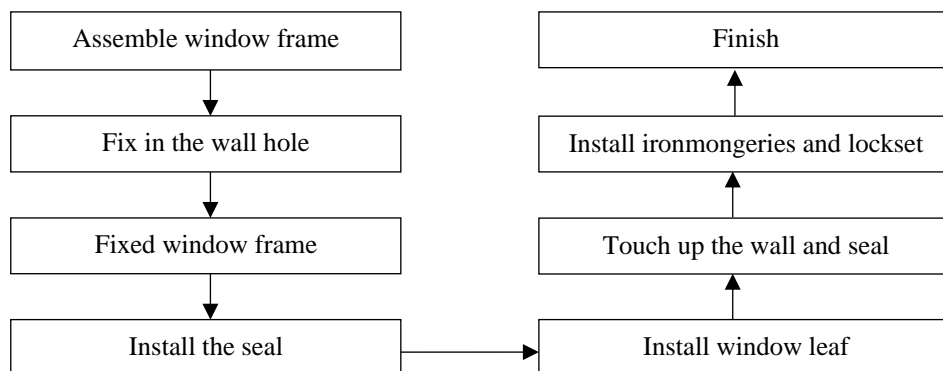


Figure 9.8 Window installation steps


- Window installation starts with the frame assembling process. Most of the time, the window frame comes in a complete set from the factory.
- The window frame is fixed in position to the wall opening which the bricklayer sets.
- Wall opening is wider than the actual size of a window to allow the fixing process.
- Levelling and setting must be accurate to ensure the window is fixed in the right position.




- v. Window frame is fixed to the wall by screwing the metal fixing cramp and the frame to the wall.
- vi. Temporary spacers and stretchers are used to prevent inward sagging and the frame from being squeezed in during fixing.
- vii. Gaps between the frame and wall surface are also fixed with brick or concrete sealer to ensure the window frame is at the right position as set earlier.
- viii. Window leaf will be placed and hinged to the frame when the frame is stable and in the right position.
- ix. After the frame and window leaf are fixed, the gap will be finished and filled with concrete mortar or brick.
- x. Ironmongeries and locksets are then fixed to the window set.






IRONMONGERIES




Ironmongeries are door and window fittings and accessories that help in its operation and securing the door and window systems. Ironmongeries are normally made of metal such as steel, aluminium, and brass. Ironmongeries must be durable and strong for security purposes. The window ironmongeries is normally attached to the system from the manufacturer. Table 9.3 lists the main ironmongeries fixed and installed in the door system.

Table 9.3 Type of ironmongeries

| Types of Ironmongeries | Description | Illustration |
|------------------------|--|---|
| Hinges | <ul style="list-style-type: none"> ▪ Hinges are door fittings that join the two parts together and form a revolute joint between them ▪ Revolute means move or rolled backwards or downward ▪ Hinges allow door leaf to rotate relative to each other at a fixed axis ▪ In other words, hinges allow door or window leaf to swing in and out |  |

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| <p>Lockset</p> | <p>Lockset serve as an entry function and security to the door system.</p> <ul style="list-style-type: none"> ▪ Usually comes in 2 types: knob (round shaped) and lever. ▪ Both locksets have a small button on the inside to allow manual door locking. ▪ Locking system works when the user pushes the button in or turns the button after pushing it in. ▪ This will cause the door to remain locked, even after a key is inserted and used. ▪ The door will be unlocked when the user turns the knob or the lever. |  <p>The image shows two types of locksets. The top one is a knob lockset with a round knob and a small button on the side. The bottom one is a lever lockset with a horizontal lever and a small button on the side.</p> |
| <p>Door handle</p> | <ul style="list-style-type: none"> ▪ Door handle is a handle used to open or close the door ▪ Door handles normally come in a set together with the locking system ▪ Normally made from stainless steel, metal and brass ▪ There are many types of door handle serving the function and also the aesthetic look of a door |  <p>The image shows two types of door handles. The top one is a vertical handle with a keyhole. The bottom one is a horizontal handle with a keyhole.</p> |
| <p>Barrel bolt</p> | <ul style="list-style-type: none"> ▪ Barrel bolts are the bracket-secured components that slide across doors to reinforce locks and provide additional security measures. ▪ They are commonly found in many domestic and commercial doors. ▪ Typically made from brass, steel or chrome, they are available in a variety of designs for use in different settings. ▪ They may also be plated to provide additional protective properties. |  <p>The image shows a barrel bolt component, which is a long, cylindrical metal piece with a bracket at one end and a locking mechanism at the other.</p> |

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| Latch barrel bolt | <ul style="list-style-type: none"> ▪ Almost similar to a barrel bolt. ▪ Normally fixed to internal doors such as bedroom door and bathroom door. |  |
| Door chain | <ul style="list-style-type: none"> ▪ Fixed to door for extra security to the ironmongeries and the door locking system. ▪ Normally made of stainless steel, metal and brass and fixed to domestic and hotel doors. |  |
| Door closer | <ul style="list-style-type: none"> ▪ Door closer is a hydraulic door device that functions to close a door after it has been opened or swing-out automatically ▪ Commonly fixed to heavy doors and fire doors as a fire prevention measure and to ensure fire doors are closed at all times ▪ It also adds security to the door closure and controls the door open swing ▪ Also helps to prevent slamming and draughts of the door |  |
| Door coat hook | <ul style="list-style-type: none"> ▪ Door coat hook does not serve as a security function ▪ As an added accessory to the door ▪ Functioning to organise users' belonging, especially when fixed to public toilet door or personal room door ▪ Must be stable and can hold up the load of the items hanging onto it |  |
| Door stopper | <ul style="list-style-type: none"> ▪ Door stopper fixed to the door system to keep the door open or stops it from banging against the wall ▪ Usually comes in a rubber-tipped device attached to a wall or floor to prevent damaging contact between an opened door and the wall |  |

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| Door knocker | <ul style="list-style-type: none"> ▪ A door knocker is a door fitting that allows people from the outside of a building or room to alert those people in the inside of their presence ▪ Fixed to the front door to facilitate people who might come and knock for admittance ▪ Consist of two parts, a plate that is fixed to the door, and an attached hinged piece, often a loop that can be lifted against the plate ▪ Also serve as a decoration and aesthetic function to the door |  |
| Indicator bolt with lever turn | <ul style="list-style-type: none"> ▪ Indicator bolt with lever is ideal for use at bathroom door or public toilet door ▪ Offers indication as to whether the bathroom is occupied or otherwise ▪ It also sometimes functions as a door handle and can be open from outside in the event of an emergency |  |
| Door peephole | <ul style="list-style-type: none"> ▪ Fixed to the door, usually at an apartment unit door or a hotel room door ▪ The peephole enables the people inside to peep out without opening the door for security reason ▪ Typically, as glass peepholes fitted with a fisheye lens to allow a broader view from the inside |  |

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* Azirah Adnan

* Sukmawati Ismail

TOPIC 10

FINISHES

INTRODUCTION

Finishes for the building are needed to beautify the building and the comfort of its occupants. Building finishes include exterior and interior finishes and consist of ceiling finishes, wall finishes and floor finishes (Abdullah. and Rashid, A.K. 2003).

In creating aesthetic and durable interior space, some factors had to be taken into consideration. These are environmental effects (heat, water, moisture, noise, light, etc.), mechanical effects and aesthetic requirements.

The layer which was created to provide these features is called "finishing layer". Finishing layer must be aesthetic, durable, and strong. In recent years, ecology of the building and finishing materials have gained importance to protect the user health and ecological balance of the world (Gulru Koca, 2017).

FACTORS THAT INFLUENCE THE SELECTION OF FINISHES

Aesthetic value/Appearance

- i. It is important for generating the sensory experience for the user to appreciate the function of the interior.
- ii. Aesthetic expectation also able to increase the value of the room, house, building, office, etc.

Cost

- i. The cost will be one of the crucial factors in selecting the finishes that include the true purchase price, best total value, stripping cost, equipment, and maintenance cost.
- ii. Variable cost and variable quality in the market that is suitable with the budget. The customer can still decorate with a reasonable budget.

High resistance/Durability

- i. Finishes are the last layer as the finishing in the construction either internal or external of the building, so the finishes' durability must be suitable to usage area such as kitchen or toilet which can be considered as huge usage area.

Sound Isolation

- i. Building codes sometimes require that a floor/ceiling assembly help isolate sound from above.

Humidity

- i. Building sometimes is subjected to risk of sagging due to moisture absorption. Hence, the choice of materials must be carefully considered. The humidity will also affect the hygiene of the finishes.

FLOOR FINISHES

Floor is the horizontal structural element of the building. Despite its function, the floor is load bearing. It can also increase the value of the building in terms of aesthetics (Gülru Koca, 2017). The finishing is needed to beautify the building as well as for the comfort of its users. Usually applied to a structured base but may form part of the floor structure such as floorboards.

The characteristics of good flooring include:

- i. Hardness,
- ii. Gloss,
- iii. Scuff resistance,
- iv. Slip resistance,
- v. Water and detergent resistance,
- vi. Removability, and
- vii. Toughness.

Flooring includes a variety of materials that are used to cover a floor permanently. There are three main categories of flooring products.

- i. Commercial designed purposes include institutional, health care, mall, retail, light industrial, office, and other commercial settings. Products include wear resistant carpets, laminate flooring, ceramic tiles, epoxy, synthetic fibre carpeting and vinyl composition tile.
- ii. Residential design is proposed for bathroom, bedroom, dining rooms, living room, lobby, foyer, kitchen, and porch. Products include ceramic tiles, granite, laminate flooring, timber floor, imprint floor and others.
- iii. Industrial designed proposed for factories, garage, warehouse. Products include floor hardener, vinyl tiles, granite, cut stone tiles of marble, ceramic tile applied with epoxy adhesive to the substrate, or terrazzo.

Types of floor finishes being used depending on the following factors:

- i. Type of base
 - ii. Room usage
 - iii. Degree of comfort required
 - iv. Maintenance problems
 - v. Cost
 - vi. Appearance,
 - vii. Safety
 - viii. Individual preference
-

TYPES OF FLOOR FINISHES

Type of floor can be categories into three by its material, parts, and method of installation. There are in situ floor finishes, applied floor finishes and timber floor finishes.

- *In-situ Floor Finishes*

Those finishes that are mixed on site, laid in a fluid state, allowed to dry, and set to form a hard jointless surface.

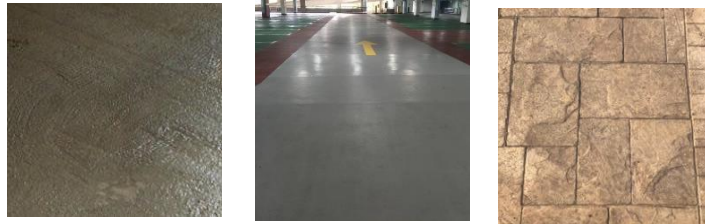


Figure 10.1 Cement, floor hardener, imprint*

- *Applied Floor Finishes*

Those finishes that are supplied in tile or sheet form and laid onto a suitably prepared base.

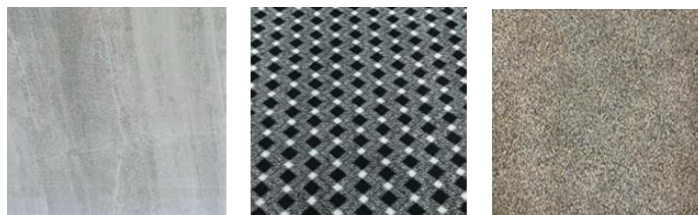


Figure 10.2 Tiles and carpet

- *Timber Floor Finishes*

Boards, sheets, and blocks of timber laid attached to a suitable structural base.



Figure 10.3 Timber floor

In Situ Floor Finishes

Cement Render

The most common material used in the construction of building, garage, warehouse, educational building, shop office is the cement screed or cement render. Cement screed flooring refers to a layer well compacted material, commonly a cement and fine aggregate mixture. The ratio for a floor screed is usually a cementitious material made from a 1:3 or 1:4.5 ratio of cement to sharp sand and used epoxy floor covering.



Figure 10.4 Process of levelling, cement rendering and trowelled finish*



Figure 10.5 Cement concrete hardening*

Method of installation

- i. Site preparation
- ii. Levelling strips
- iii. Apply cement screed - A cement screed of 20-40 mm thick with levels according to the requirement is cast on concrete. Used ratio (1:3) cement and sand mix.

- iv. Reinforcing a screed - Reinforcing a screed is needed when there is pipework in the screed. Mesh reinforcement is recommended over the pipework.
- v. Float- Finishing
 - surface of the newly laid cement render with a mixture of cement, sand & water, cement powders are placed on the surface before smoothing by trowelling.
 - For light to medium duty usage such as low-cost houses, garage, store used trowelled finish.
 - For large areas such as basement, carpark, used power float finish.

Floor Hardener

- Cement and sand mix with hardener
- Available in various colours
- Hard surface – suitable for heavy duty traffic such as carpark, factory, pedestrian
- Polymeric floors are poured as liquids and spread out across surfaces to harden and cure. This creates a finish without seams and makes them particularly suitable for industrial or commercial applications.



Figure 10.6 Kuala Lumpur International (KLIA) carpark*

Method of Installation

- i. This floor hardener is to be placed by hand or material spreader (Standard ACI 302 Method).

- ii. Screeding and fill floating (bull floating)
- iii. After excess bleed water has evaporated or has been removed but leaving sufficient moisture at the surface to hydrate cement binders in the floor hardener, evenly distribute approximately 2/3 of the hardener specified for the area.
- iv. Immediately apply the remaining 1/3 of the specified amount of hardener. The moisture from the underlying concrete must be completely worked through the hardener.
- v. After the concrete has further stiffened, it should be machine or hand trowelled to a blemish free finish.

Concrete Imprint Flooring

Concrete Imprint Flooring comprises the preparation of sub-base to receive fabric reinforcement and in-situ concrete of selected grade to form attractive and sturdy floor.

Concrete Imprint is designed for use on all hard surface areas where an appealing, robust, low maintenance surface finish is required for either pedestrian or vehicle traffics.

Suitable area

Pedestrian walkways, parking areas, roads and lanes, shopping malls, municipal parks, forecourts, car porches, swimming pool surroundings, and others.

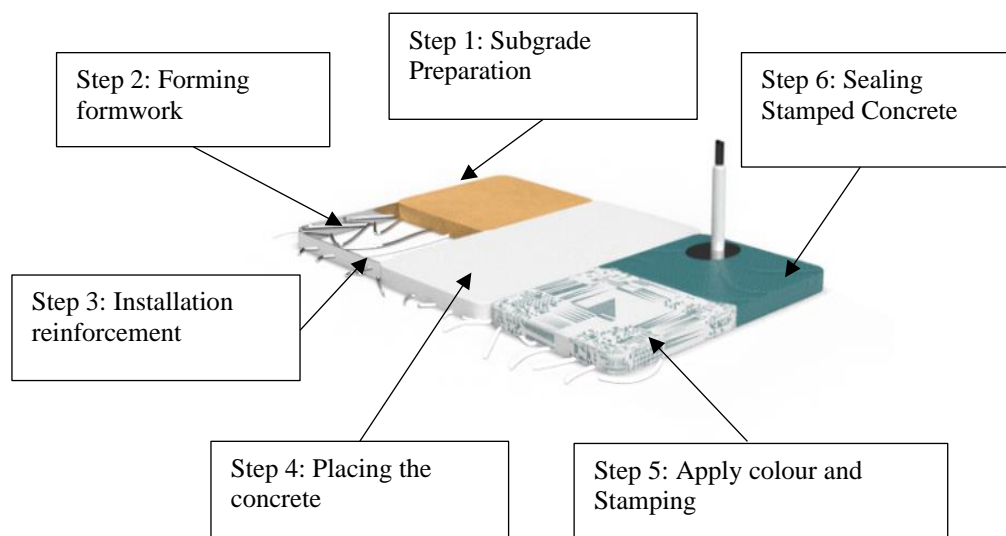


Figure 10.7 Concrete Imprint Installation*

Benefits of Concrete Imprint

- i. Reduced long-term maintenance
- ii. Increased life span
- iii. Increases resale value of property
- iv. Cost effective
- v. Easy to construct

Basic Material

- i. Colour hardener
- ii. power release agent
- iii. solvent-based acrylic sealer
- iv. Imprint stamp mould



Figure 10.8 Variety imprint floor*

Applied Floor Finishes

Applied floor finishes is a manufactured piece or rolled material such as carpet, ceramic, stone, glass, and other materials suitable for floor finishes. This method is opposing off in-situ floor finishes since this method used manufactured material. This flooring provides property owners with the opportunity to have a resistant, durable, and reliable floor installed in their home or business premises.

Carpet

Carpet tiles, also known as modular carpet, is a popular flooring option for commercial environments and other relatively uncomplicated spaces. It is designed to be used in high traffic areas with a variety of colours and patterns.

Carpet tiles are also lightweight, flexible, and have a backing stabilizer, making it easy to work with. Carpet tiles is easy to install besides the ease of removal. Besides that, this material allows acoustic insulation suitable for bedroom, educational, prayer spaces and others.

- Materials – nylon, acrylics, and wool
- Available in various patterns, colours, qualities, and sizes
- Obtain maximum life – should be laid over an underlay of felt or latex
- Secured by adhesives, nailing around the perimeter, and attached to special edge-fixing strips
- Supplied in rolls or tiles

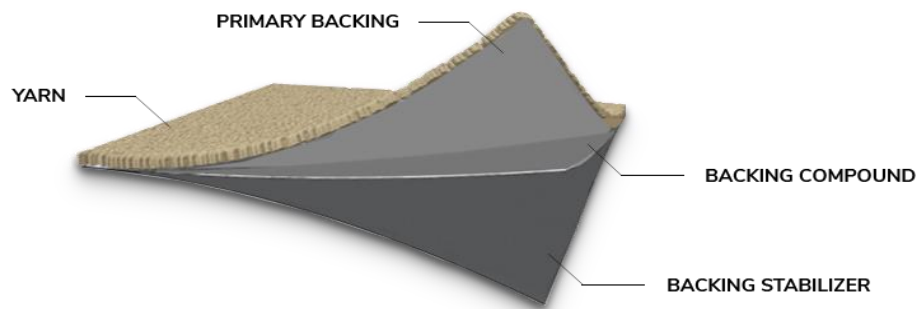


Figure 10.9 Section of basic carpet tiles

Carpet Installation



Figure 10.10 Carpet installation at Masjid Al- Amin Kampung Jong, Gerik, Perak*

Adhesive Installation

- i. Direct glue down – economical and fast / used for stairs, ramp / requires an even and hard surface base
- ii. Double Glue Down – glue down carpet cushion, then glue down carpet
- iii. Self-Stick – a flexible adhesive layer is applied to the carpet backing and is covered with a protective plastic film

Ceramic Tiles

Ceramic tiles are made up of sand, natural products, and clays. From refined natural clays which are pressed after grinding, tempered into the desired shape before being fired at high temperature. All rigid tiles are shaped from natural earthen clays and hardened by heat. Most ceramic tiles are porcelain. This type of tiles is the most popular and suitable for normal domestic used such as kitchen, bedroom, living, dining, and toilet.

- i. Light to medium duty usage
- ii. Easy to clean and high resistance to dampness penetration
- iii. Type range – glazed, unglazed, anti-slip
- iv. Surface finishing can be Matt, glossy and other suitable material.

v. Product in square tiles varies:

- 300 – 800 mm (L)
- 150 – 600mm (W)
- 8-9mm (T)

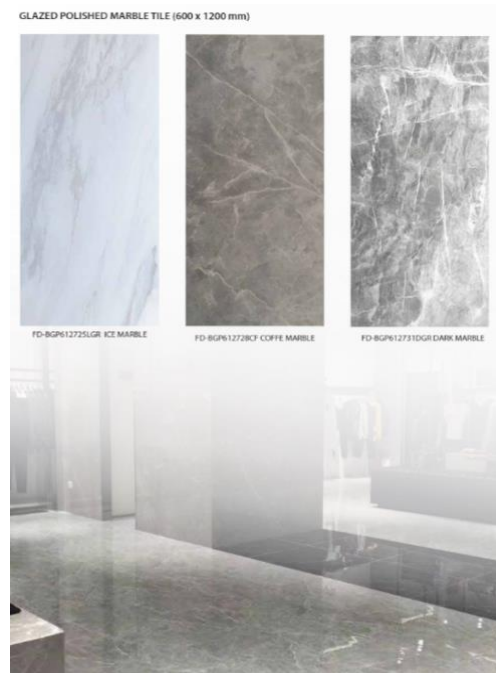


Figure 10.11 Variety of tiles

Installation Method of Ceramic Tiles

Step 1: Prepare the surface. Make sure your surfaces are clean, smooth, and dry for best results

Step 2: Prepare layout, starting with measuring the center point of each of the walls in the room

Step 3: Lay out the tiles for testing

Step 4: Prepare selected tiles and cut (if necessary).

Step 5: Apply the adhesive

Step 6: Lay out the tiles. Tiles can be set from in the middle of room or layout

Step 7: Grouting tiles

Step 8: Cleaning and sealing

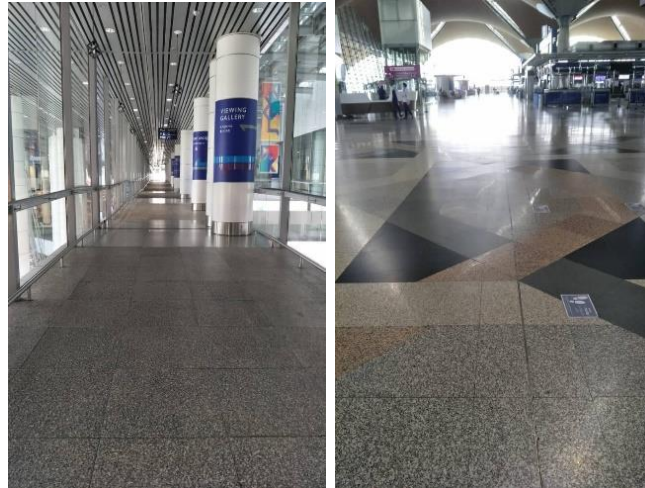


Figure 10.12 Tiles at Kuala Lumpur International Airport (KLIA) *

TIMBER FLOOR FINISHES

Timber flooring is designed for use as flooring, either as structural or aesthetic. Wood is a common choice for flooring material due to its environmental profile, durability, and restorability. There are other types of timber floor like parquet, floorboard, timber board, and laminate flooring (Lai et al., 2016). Wood or timber flooring is one of the popular choices for clients seeking attractive traditional, modern styles for residential and commercial. Due to the difficulty in obtaining the material, timber flooring is one of the expensive floors finishes nowadays.

The common type comprises parquet, timber strip, solid wood, engineer flooring and laminate timber flooring.

Parquet

- Composed of short strips or blocks of wood forming a pattern led to a variety of designs.
- Made from specially selected hardwood such as Jati and Kempas, chosen mainly for their decorative appearance
- Suitable for living room, bedroom, dining and mostly used in internal space.

- High sound and water absorption
- Fixing – by adhesive or secret nailing



Figure 10.13 Parquet*



Figure 10.14 Apply adhesive on subfloor

Laminate Timber Flooring

- Achieved with tongue and groove interlocking composite strip floor system
- Strip size – 1210mm long, 20-180mm width and thickness 7-14mm
- Some system is glued along tongue and groove and others simply snap lock together
- Components of fixing.
- Underlay – damp proof plastic foil
- Sublayer – structural concrete or screed
- Movement – 8-12mm expansion gap (room edge)

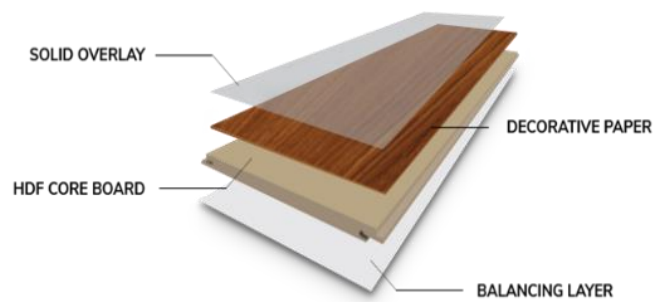


Figure 10.15 Layer of laminate timber

Laminate timber flooring is easy to clean, water resistance, stain resistance, scratch resistant, easy maintenance and easy to install. Laminate flooring comes in attractive and authentic designs and styles. Based on market demands, laminate flooring varies to cater to the need for waterproof and super water-resistant flooring solutions (Floor Depot,2021)

Suitable area:

- i. All residential
- ii. Light commercial
- iii. Moderate commercial



Figure 10.16 Laminate timber flooring at staircase*

Vinyl Flooring

Vinyl flooring is a great choice, particularly for kitchen and bathroom applications. With its water-resistant, stain-resistant, versatile, and durable characteristics, vinyl flooring is suitable for residential homes and commercial settings where high traffic is constant. In homes, vinyl flooring is often used in high moisture areas such as kitchens and dining rooms where a significant amount of moisture is expected as minimal maintenance is required.

Features

- UV layer - clear topcoat to protect from fading
- Wear layer – clear wear layer to protect the decorative paper
- Decorative paper – hi-resolution printed wood image
- Glass fiber layer – give support to other layers and allows to lie flat and even
- Balance layer – gives further foundational support, strength, and ease of installation



Figure 10.17 Vinyl flooring for living

The vinyl flooring is more economical compared to other types of flooring. It is easy to install and has easy maintenance. The flooring is termite proof, acoustic insulation, waterproof, scratch-resistant, easy to clean and anti-slip.

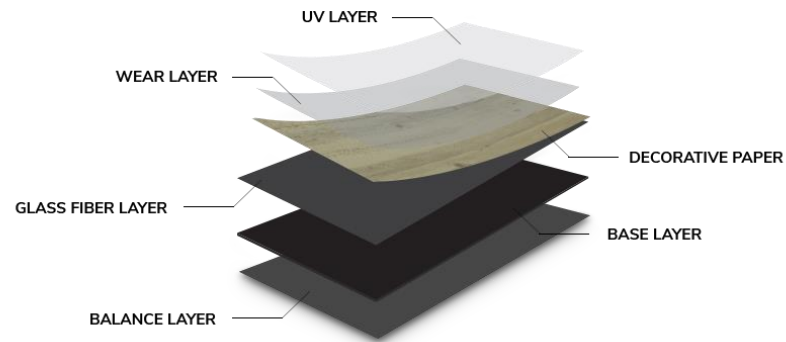


Figure 10.18 Layer of vinyl flooring

Method of Installation of Vinyl

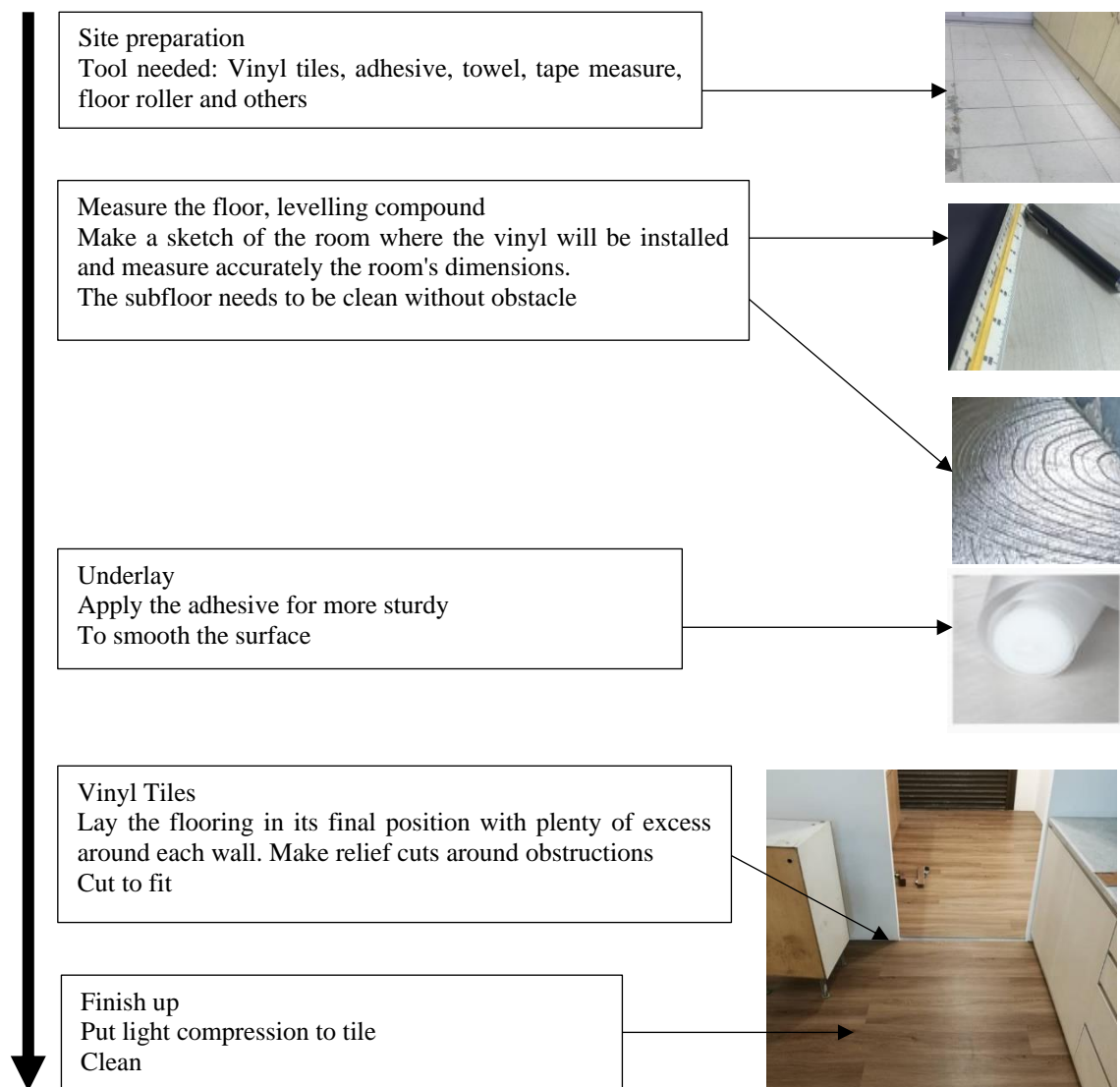


Figure 10.19 Vinyl flooring*

WALL FINISHES

The name 'Wall Finishes' suggests that it is the finish given to the wall to enhance the interior and exterior look of the structure. Wall finishes used for the interiors are quite delicate and need maintenance.

Wall finishes provide a decorative skin to conceal building components, including structural members, insulation, ductwork, pipes, and wires.

Good wall finishes are plumb and straight. Surfaces may be smooth or textured, and better wall finishes are durable. Some wall finishes are versatile, taking decorative finishes such as stain, paint, or wallpaper readily.

The type of wall finishes that will be used depends on several factors: the type of base, room/space usage, degree of comfort required, maintenance problems, cost, aesthetic appearance, and individual preference. There are many types of walls finishes such as plaster and paint, wallpaper, tiles, cladding and so on.

For example, external walls of common clay bricks can be treated to give an acceptable appearance by applying plaster and paint or with an extra budget, and tiles can be applied.

Plaster

Plaster, a composition (of lime or gypsum, water, and sand) that hardens upon drying and is used for coating walls, ceilings, and partitions. It is commonly used for the interior and exterior of the building. The most common types of plaster mainly consist of gypsum, lime, or cement, but all work similarly. Plastering is done after bricklaying work. There are two types of plaster: Gypsum Based and Cement Based. Cement based plaster is commonly used in Malaysia. Plastering work needs to be done by skilful workers to acquire smooth surface and beautiful plastering work. Plaster can be repaired if a defect occurs.

Table 10.1 Advantages and Disadvantages of Plaster

| Advantages | Disadvantages |
|--|--|
| <ul style="list-style-type: none">• Decorative Appeal• Durability• Easier installation | <ul style="list-style-type: none">• Repairing difficulties• Expensive |

Installation Method of Plastering

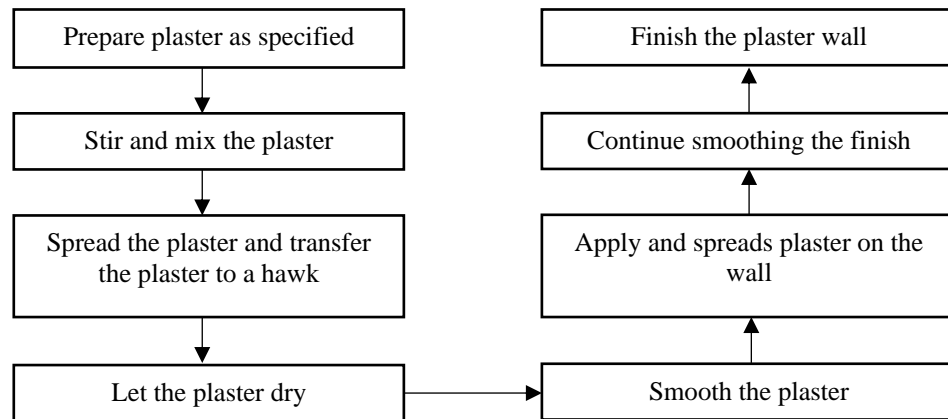


Figure 10.20 Installation method of plastering



Figure 10.21 Plastering an internal wall and plaster to wall using steel trowel



Figure 10.22 Plastering work site Project Klinik Kesihatan Kok Lanas, Kelantan*



Figure 10.23 Plastering tools and accessories

Painting

Paint is any kind of liquid, liquefiable that will turn into a solid form or film after application to a surface in a thin layer. It is mostly used to protect, colour and provide texture to a surface. It can be made and purchased in any type and any colour, according to the buyer preference. Paint is usually stored, sold, and applied as a liquid. It can be applied to wall for interior and exterior purposes and ceiling.



The functions of paint are:




- i. to protect the material from weathering, oxidation process and damages by insects.
- ii. to improve the appearance of the material
- iii. to facilitate the cleaning process of the surface
- iv. to provide light – and heat–reflecting properties



Figure 10.24 Paint to wall using weather shield paint*

Table 10.2 Type of paint

| Types of paint | Function | Product Example |
|------------------------------------|--|--|
| Primer | Apply to the surface to be painted |  |
| Emulsion paint (water-based paint) | Give a shoddy finishing (not shiny) and suitable for brick wall and concrete wall (exterior and interior wall) |  |

| | | |
|------------------------------------|--|--|
| Enamel paint (solvent-based paint) | Used as a basic paint for the surface of wood, metal works or concrete |  |
| Oil paint (oil-based paint) | Used to all surfaces especially on indoor wood and metal works |  |
| Varnishes | Gives a transparent finish to the wood. |  |

How to Paint

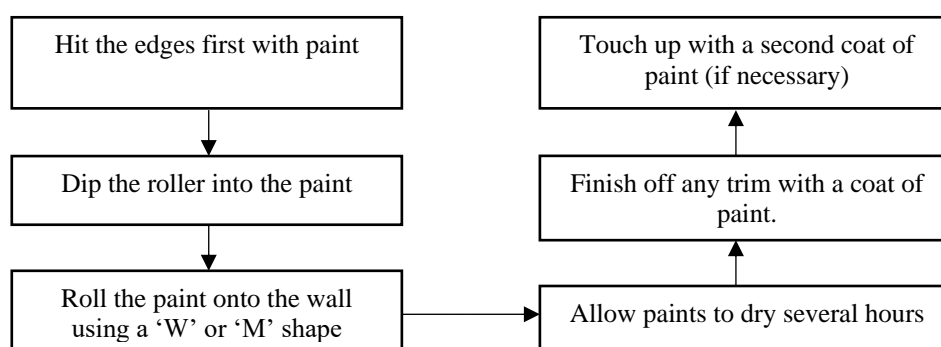


Figure 10.25 Installation method

Wallpaper

Wallpaper is a kind of material used to cover and decorate the interior walls of the building, and it is one aspect of interior decoration. It is usually sold in rolls and is put onto a wall using wallpaper paste. It has a variety of patterns, colours and finishes. Wallpaper is another popular alternative besides painting due to the variety of patterns, colours and finishes. The colour and design of wallpaper can make a room look spacious and more stylish. There are few types of wallpaper such as painted wallpaper, hand printed block wood wallpaper, hand printed stencil wallpaper, machine printed wallpaper and flock wallpaper. Wallpaper comes either with adhesive or without adhesive.

Table 10.3 Advantages and disadvantages of wallpaper

| Advantages | Disadvantages |
|---|--|
| <ul style="list-style-type: none">• Variety of design• Environmentally materials• Easy to install | <ul style="list-style-type: none">• Not particularly strong• Prone to burnout if exposed to sunlight• Low noise insulation• Low moisture resistance |

Wallpaper Adhesives

Most wallpaper adhesives are starch or methylcellulose based.



Figure 10.26 Wallpaper adhesive

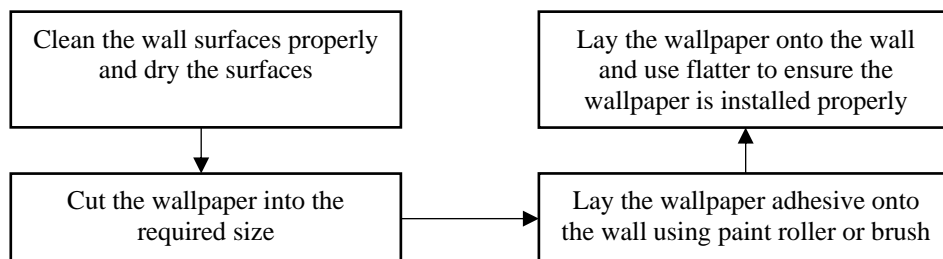


Figure 10.27 Method of installation for wallpaper



Figure 10.28 Sample of wallpaper design

Tiles

Tile is a manufactured piece of hard-wearing material such as ceramic, stone, glazed tiles and marble, which is generally used for covering roofs, floors, walls, or objects. Tiles are often used to form wall and floor coverings and range from simple square tiles to complex mosaics. Tiles are most often made from ceramic, while tiling stones are typically marble, granite or slate. Thinner tiles can be used on walls than on floor because it requires more durable surfaces that will resist impacts.

Installation method

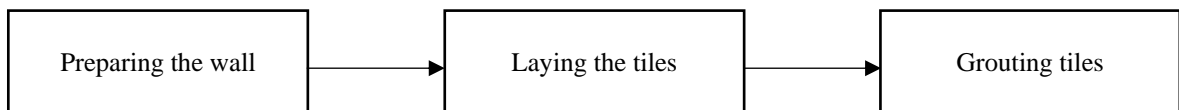



Figure 10.29 Installation of tiles

Table 10.4 Type of tiles

| Type | Suitability | Pictures |
|----------|---|----------|
| Terrazzo | Residential floor and wall – Indoor <ul style="list-style-type: none">• Living• Dining• Dry kitchen• Wet kitchen• Bathroom• Bedroom• Feature wall Commercial floor and wall – Indoor <ul style="list-style-type: none">• Shopping mall• Hotel• Lobby• Retail• Cafe• Restaurant• Walkway | |

| | | |
|------------------------|--|--|
| <p>Glazed Tile</p> | |  |
| <p>Porcelain tiles</p> | |  |

| | | |
|-------|--|--|
| Stone | |  |
|-------|--|--|

CEILING FINISHES

A ceiling is part of a building that encloses a space and is exposed overhead. According to Gülru Koca (2017), the ceiling is the lower part of the floor. Ceiling finishes is to provide different surface textures applied to the internal or exterior ceiling. Generally, ceiling finishes do not have direct contact with water. But, the performance of material against water is important in wet areas (Gülru Koca, 2017). So, the selection of material and type of ceiling is also influenced by several factors.

Several factors to be considered when determining the suitable ceiling type and finishes:

- i. Aesthetic Expectations - Ceiling finish materials, heights, and profiles can create appealing environments and influence the vibe of the spaces and increase the value of the building or room
- ii. Conceal the Building Utilities Overhead (mechanical and electrical equipment and components) - All the cable, wiring, and plumbing included must be accounted for
- iii. Wind Loading - Wind loading should be considered for buildings that have major openings
- iv. Humidity - Some buildings have major openings, such as banks, hotel lobby, and others, where the building is exposed to moisture

- v. Flammability - Fire rated materials should be used to give ample time for occupants to vacate the building
- vi. Sound Absorption and Sound Isolation - Suitable for educational buildings, hospitals, prayer spaces and others, where sound absorption is required
- vii. Cost - Cost of material, installation and maintenance should be considered wisely for the long term

Type of Ceiling Finishes

Suspended Ceiling

There are several ways of finishing a ceiling, namely suspended ceilings, plasterboard and skim, composite wood ceiling, and exposed ceiling.

Suspended ceilings are secondary ceilings suspended from the structural floor slab above, creating a space for mechanical, electrical, and plumbing components. They are also known as dropped ceiling or false ceiling. It is one of the most popular types of ceiling used in houses, office buildings, educational buildings, and others. However, the problem with this type of ceiling is the relatively high possibility of defect.



Figure 10.30 Ceiling defect*

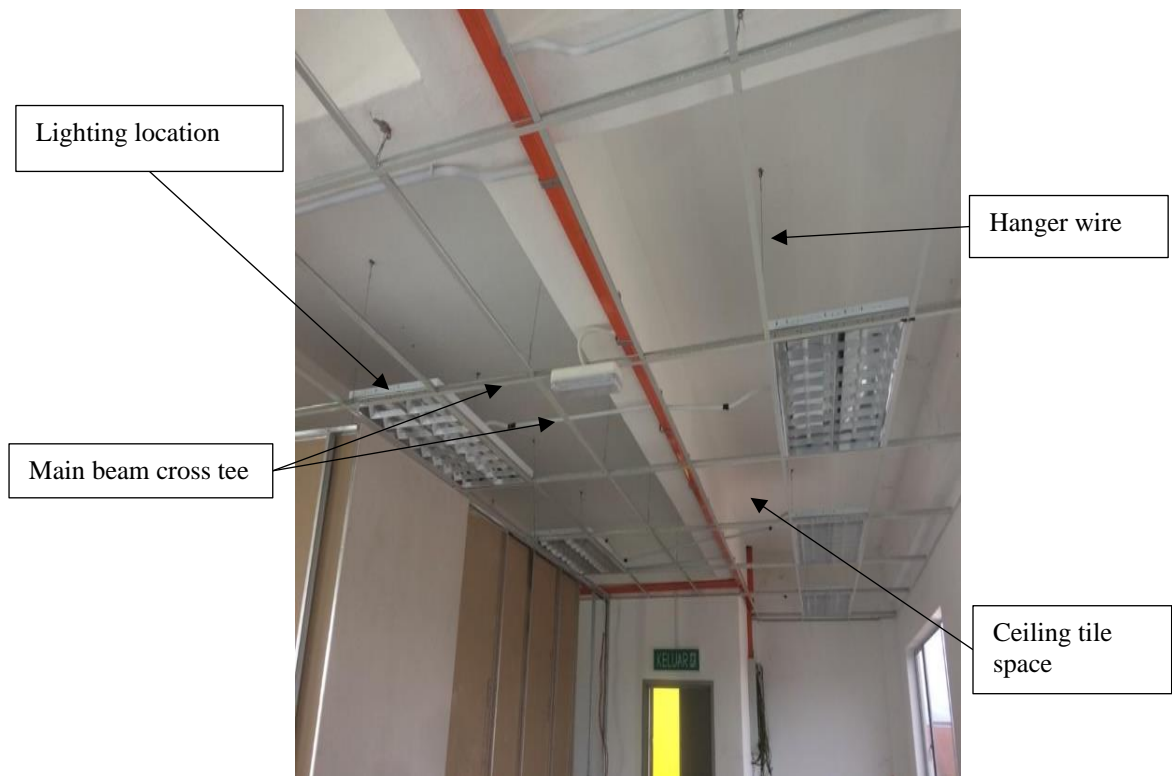


Figure 10.31 Suspended ceiling component*

Method of installation

- Step 1: Setting the perimeter
- Step 2: Draw a room scale
- Step 3: Choose the lighting location
- Step 4: Attach wall angles
- Step 5: Install wiring
- Step 6: Attach suspension wires
- Step 7: Tie Together the main tees and cross tees



Figure 10.32 Finish up suspended ceiling*

Composite Wood Ceiling

Timber has been used in the construction industry for the countless year. Timber ceilings deliver a broad range of benefits to the building with properties such as excellent insulators, require little-to-no maintenance, provide natural aesthetics look, and acoustic benefits, making it a highly desirable material in many construction projects.



Figure 10.33 Sample of timber ceiling at UiTM Kampung Gajah, Perak*

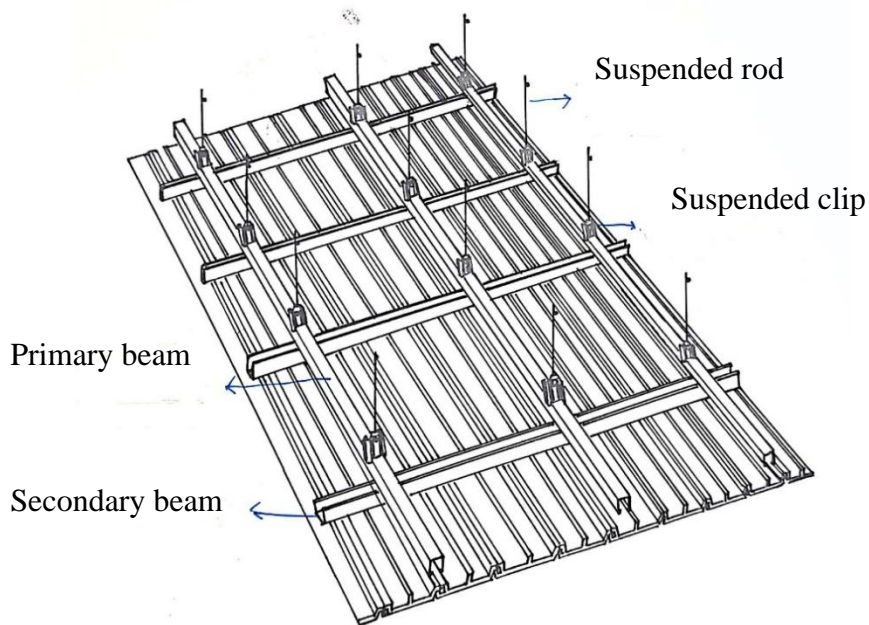


Figure 10.34 Typical ceiling installation*

Method of installation

i. Site Preparation

- Ensure that all related/conjunction service, i.e., plumbing, electrical, air-conditioning work, is done before starting any installation work.
- Get ready a proper/ secured/ sheltered place for temporary storage and working space.
- Ensure that safe access and safe working conditions, i.e., scaffoldings (if required), are placed before starting any installation work.

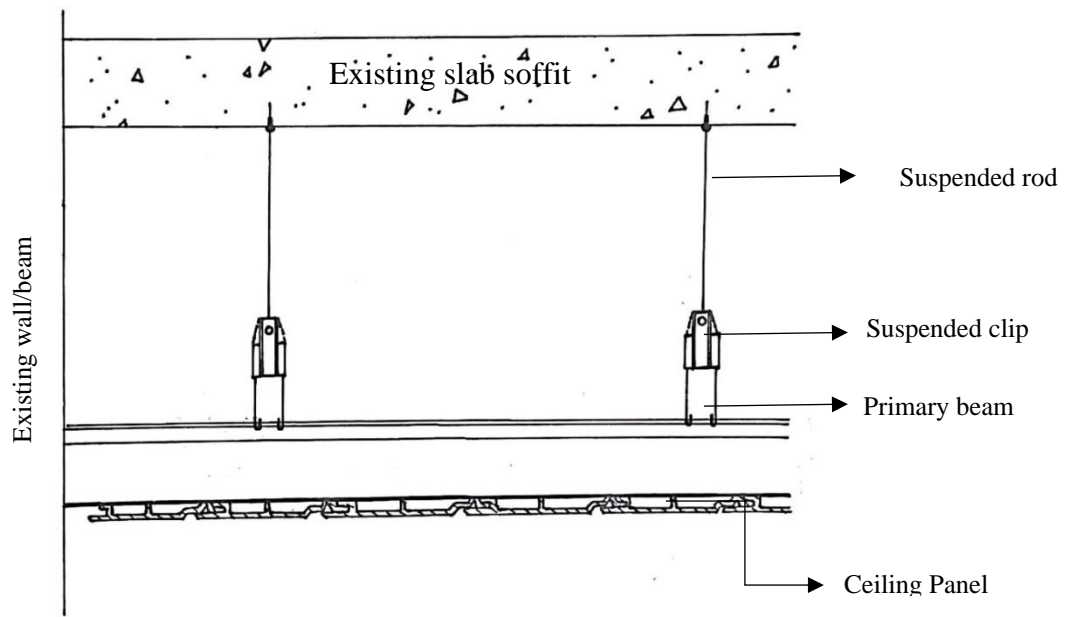


Figure 10.35 Cross section of ceiling*

- ii. Fixing the First Ceiling Panel
- iii. Fixing the Second Ceiling Panel
- iv. Fixing the Next Ceiling Panel
- v. Fixing the Closing Ceiling Panel

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*Fairiz Miza Yop Zain

*Mohamad Tajudin Saidin

TOPIC 11

PLANT AND MACHINERY

INTRODUCTION

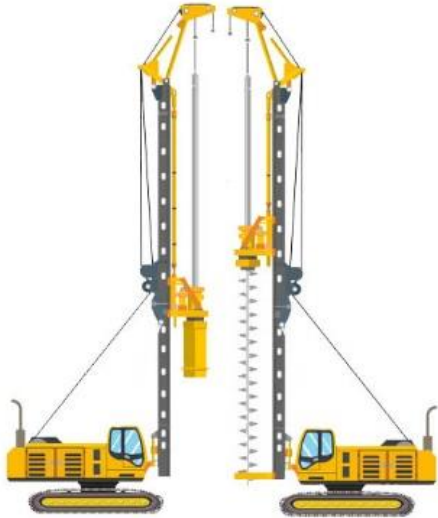

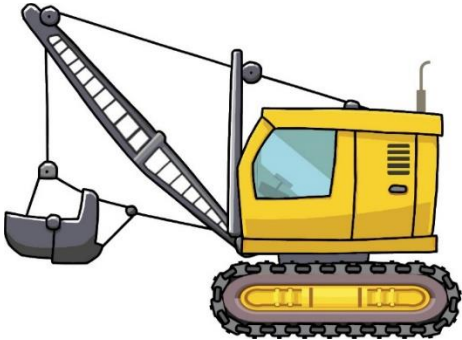
In construction, a construction company considers plants and machinery as an asset to carry out work required to be done by the contractor. The difference between plant and machinery is that machinery will have moving working parts, but not for plant. Through innovation and development of plant and machinery for the construction industry businesses, it is sometimes difficult to differentiate between the two. Yet, it is not an issue for the construction industry, as both plants and machinery are usually grouped under a single bill inside the Bills of Quantities (BQ). This chapter introduces the readers to the common plants and machinery used in a construction project.





PLANT AND MACHINERY



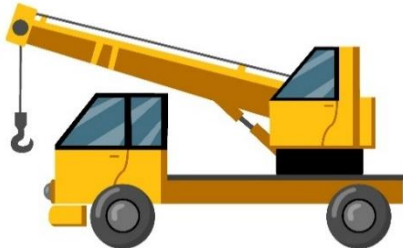

Some of the common plants and machinery used for a construction project are listed as follows:





Table 11.1 Plant and machineries

| No | Plant and Machineries | Function |
|----|----------------------------|--|
| 1. | Piling Rig/ Piling Machine | <p>A piling rig is used to drive piles into the soil in providing foundation support for buildings, bridges and other structures.</p> <p>A heavyweight is used and placed between a guide allowing it to move up and down in a single line. A piling rig is powered using diesel or hydraulics. The weight is then released at its optimum height, which hammers the pile and drives it into the ground.</p> |



| | | |
|----|---|---|
| |  | <p>There are many types of piling rigs available on the market, as different types of piles will require different types of rigs.</p> |
| 2. | <p>Backhoe</p>  | <p>A backhoe is also called a rear actor or back actor. It is a type of excavating machinery consisting of a digging bucket on the end of a two-part articulated arm. It is typically mounted on the back of a tractor or front loader.</p> |
| 3. | <p>Dragline</p>  | <p>Draglines are primarily used for open-pit operations. Draglines fall into two broad categories: those based on standard, lifting cranes, and the heavy units that have to be built on-site.</p> <p>The types of dragline machine use in a construction project are usually based on their bucket capacity.</p> |

| | | |
|----|--|--|
| 4. | <p>Excavator</p>  | <p>Excavators are also known as diggers. It is a type of excavating machinery consisting of a boom, dipper, bucket and cab on a rotating platform known as the "house".</p> <p>The types of excavator machine use in a construction project are usually based on their bucket capacity.</p> |
| 5. | <p>Face Shovel</p>  | <p>A face shovel is an excavation machine that has a rope or hydraulically operated bucket. It removes soil from the base of excavations in a direction away from the machine.</p> <p>Like any excavation machinery, the types of face shovel use in a construction project are usually based on their bucket capacity.</p> |
| 6. | <p>Back pusher</p>  | <p>A back pusher is typically a tractor equip with a shovel mounted at the end. The function of a back pusher is usually used for levelling soil on the ground.</p> |
| 7. | <p>Bulldozer</p>  | <p>A bulldozer is a large motorised machine that travels on tracks and is equipped with a metal blade to the front for pushing material during construction works or earthworks.</p> <p>The types of bulldozer use on a construction site usually depend on its use or function in a construction project and horsepower capacity for a job.</p> |

| | | |
|-----|---|---|
| 8. | <p>Tractor</p>  | <p>A tractor is a machine to haul a trailer or machinery such as those used in agriculture, mining or construction.</p> |
| 9. | <p>Motor Grader</p>  | <p>A grader, also commonly referred to as a road grader, motor grader, or simply a blade.</p> <p>It is equipped with a long blade underneath for surface grading.</p> <p>The types of motor grading use in a construction site are usually based on their blade length and engine capacity to fulfil the scope of work.</p> |
| 10. | <p>Mobile Crane</p>  | <p>A mobile crane is a cable-controlled crane mounted on crawlers or rubber-tyred carriers. They are equipped with a hydraulic-powered telescopic boom.</p> <p>The types of mobile crane in a construction project are usually based on their telescopic boom capacity and strength capacity to lift construction materials or plants around the site.</p> |
| 11. | <p>Vibrating Roller</p>  | <p>Vibratory rollers are widely used for the compaction of coarse-grained soil or gravelly soil. The selection of a vibratory soil compactor is vital in raising the level of soil efficiency to construct a strong building.</p> <p>The types of vibrating roller used in a construction project are usually based on their roller weight and size. Other factors such as soil condition, the size of the project, and the usage of the vibrating machine are considered in determining the most suitable type to be used.</p> |

| | | |
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| 12. | <p>Road Roller</p>  | <p>A road roller (sometimes called a roller-compactor, or just roller) is a compactor-type machine. Similar rollers are used for landfills or in agriculture.</p> <p>Initial compaction of the substrate on a road project is done using a padfoot drum roller, which achieves higher compaction density due to the pads having less surface area.</p> <p>The types of steel roller used in a construction project are usually based on their roller weight and size. Other factors such as soil condition, the size of the project, and the usage of the vibrating machine are considered in determining the most suitable type to be used.</p> |
| 13. | <p>Low Loader</p>  | <p>A low loader is used for transporting construction plant or machinery inside and outside a construction site.</p> |
| 14. | <p>Lorry</p>  | <p>A lorry or truck is used for transporting construction materials around and outside a construction site.</p> <p>The types of truck in a construction project are usually based on the truck's weight capacity.</p> |
| 15. | <p>Dumper</p>  | <p>A dump truck, also known as a dumper truck or tipper truck, is used to transport dumps around and outside the construction site.</p> <p>A typical dump truck is equipped with an open-box bed. The open-box bed is hinged at the rear and equipped with hydraulic rams to lift the front. This allows the material in the bed to be deposited onto the ground.</p> <p>The types of dumper or tipper in a construction project are usually based on their box volume capacity and the weight a truck can carry.</p> |

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| 16. | Concrete mixer | <p>A concrete mixer or cement mixer is a device that is used to mix cement, aggregate such as sand or gravel, and water to form concrete.</p> <p>A typical concrete mixer uses a revolving drum to mix the components.</p> <p>The types of concrete mixer use on construction site depend on their drum volume capacity. Other factors such as the size of the project and the concrete volume required are considered in determining the most suitable type of concrete mixer.</p> |
| 17. | Water Pump | <p>Water pumps are used at construction sites for dewatering or removing excess water accumulation.</p> <p>Water can build up due to heavy rain or high water table. Having a water pump allows the contractor to remove the water quickly to minimise downtime.</p> <p>Water pumps suitable for these applications vary. Water pumps can be powered by electric, gas, hydraulic, or manual.</p> |
| 18. | Welding and cutting set | <p>Welding and cutting set has many uses. Its function covers welding, cutting, heating, straightening, and descaling. The equipment itself is versatile, portable and is widely used in the construction site.</p> <p>There are two common types of welding and cutting set. They are oxy or fuel gas and electric.</p> |

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| 19. | <p>Generator set</p>  | <p>A generator set is a piece of portable equipment consisting of an engine and an alternator or electric generator used to provide energy.</p> <p>Generator set is often used on a construction site to provide power for certain tools when required.</p> <p>The generator set used in a construction project is usually based on their voltage supply capacity required.</p> |
| 20. | <p>Compressor</p>  | <p>A compressor is a mechanical device that increases the pressure of a gas. An air compressor is a specific type of gas compressor.</p> <p>An air compressor is considered a pneumatic device that converts power (using an electric motor, diesel or gasoline, etc.) into potential energy stored in pressurised air.</p> <p>Air compressors are designed for various power sources usage in mind, such as power tools that required air pressure.</p> |

RESOURCES

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All enquiries or queries concerning
this textbook should be addressed to:



**Royal Institution of Surveyors Malaysia
(Quantity Surveying Division)**

3rd Floor, Bangunan Juruukur, 64 & 66, Jalan 52/4

45200 Petaling Jaya, Selangor Darul Ehsan

Tel: 603-79551773 / 79569728

Fax: 603-79550253

Email: qsdiv@rism.org.my

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